

THE ROLE OF PHYSICAL ACTIVITY AND PERCEIVED ADEQUACY ON
CARDIORESPIRATORY FITNESS IN CHILDREN WITH DEVELOPMENTAL
COORDINATION DISORDER

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Submitted in partial fulfillment of the requirements for the
degree of Master of Science in Applied Health Sciences

(Health Sciences)

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ACKNOWLEDGEMENTS

When arriving to Canada almost two years ago I had little knowledge of what the future holds for me. The opportunity to become a master student at Brock University in the Faculty of Applied Health Sciences held a great challenge for me. There are many dear people who I would like to thank, that helped me to complete this investigation and this stage of my life.

To my supervisors Dr. Brent E. Faught and Dr. Panagiota Klentrou who were willing to accept the risk of taking me as a graduate student although they knew little about me. They both provided the support and resources which enabled me to pursue this research together with a valuable educational direction. Their advice and patience for every question helped me to bond all the information into one piece. I wish to thank them for building my confidence with my English. It took me time to realize that my abilities in this unique language are not as dreadful as I believed.

I express my gratitude to Dr. John Cairney and Dr. John Hay for being part of my committee and for taking time out of their hectic schedules to assist me. They helped me to focus my thoughts and ideas and guided me how to use all my intriguing data into a simple thesis story. I also thank my external committee member, Dr. Greg Wells, from University of Toronto, for his insights and advice.

Many thanks go to the PHAST team and especially to Nadilein Tjepkema, PHAST project coordinator. Her rapid and detailed responses to every question and request that I had were a huge help during this process.

Also, I thank Sally Berg, a graduate student that worked on the same project and assisted me with the accelerometers data analysis.

Thanks to Debbie Crosswaithe, Bev Minor, and Jane Deman. I always left their office with a smile and with the information that I needed which helped my graduate studies run smoothly. In addition, many thanks to Dr. Mike Plyley the associate dean and professor of the research and graduate studies in the Faculty of Applied Health Sciences, who accepted me to his program and recognized my former studies at the Hebrew University in Jerusalem, Israel.

Special thanks to Dr. Bareket Falk and Raffy Dotan for opening their house and helping to Rotem and me in our first steps in Canada. They made us feel at home miles away from Israel. I want to thank Dr. Falk for being there whenever I needed any kind of advice. In addition, to thank Raffy for all his technical help with the metabolic cart.

I wish to thank my dearly loved parents and my family who motivated and supported me in all the ways possible and who always stand by me throughout the years. Being away from them all was by far the hardest challenge during this journey.

Most of all, I would like to express my utmost thanks to Rotem. Without your encouragement and emotional support nothing would have been accomplished. You always inspires me with your strive to seek for the next adventure in life. I can not wait to see what the future holds for us together and as individuals.

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ABSTRACT

Silman, A., Klentrou, P. Hay, J., Cairney, J. and Faught, B.E. (2009). *The Role of Physical Activity and Perceived Adequacy on Cardiorespiratory Fitness in Children with Developmental Coordination Disorder*. Brock University, St.Catharines, Ontario, CANADA.

Evidence suggests that children with developmental coordination disorder (DCD) have lower levels of cardiorespiratory fitness (CRF) compared to children without the condition. However, these studies were restricted to field-based methods in order to predict VO_2 peak in the determination of CRF. Such field tests have been criticised for their ability to provide a valid prediction of VO_2 peak and vulnerability to psychological aspects in children with DCD, such as low perceived adequacy toward physical activity. Moreover, the contribution of physical activity to the variance in VO_2 peak between the two groups is unknown. The purpose of our study was to determine the mediating role of physical activity and perceived adequacy towards physical activity on VO_2 peak in children with significant motor impairments. This prospective case-control design involved 122 (age 12-13 years) children with significant motor impairments ($n=61$) and healthy matched controls ($n=61$) based on age, gender and school location. Participants had been previously assessed for motor proficiency and classified as a probable DCD (p-DCD) or healthy control using the movement ABC test. VO_2 peak was measured by a progressive exercise test on a cycle ergometer. Perceived adequacy was measured using a 7-item subscale from Children's Self-perception of Adequacy and Predilection for Physical Activity scale. Physical activity was monitored for seven days with the Actical® accelerometer. Children with p-DCD had significantly lower VO_2 peak (48.76 ± 7.2 ml/ffm/min; $p \leq 0.05$) compared to controls (53.12 ± 8.2 ml/ffm/min), even after correcting for fat free mass. Regression analysis demonstrated that perceived adequacy and physical activity were significant mediators in the relationship between p-DCD and VO_2 peak. In conclusion, using a stringent laboratory assessment, the results of the current study verify the findings of earlier studies, adding low CRF to the list of health consequences associated with DCD. It seems that when testing for CRF in this population, there is a need to consider the psychological barriers associated with their condition. Moreover, strategies to increase physical activity in children with DCD may result in improvement in their CRF.

LIST OF ABBREVIATIONS

| | |
|----------------------|--|
| α | Alpha |
| ANOVA | Analysis of variance |
| BMI | Body Mass Index |
| CRF | Cardiorespiratory Fitness |
| CSAPPA | Children's Self-perception of Adequacy in and Predilection for Physical Activity |
| DCD | Developmental Coordination Disorder |
| FFM | Fat Free Mass |
| HR | Heart Rate |
| mABC-2 | Movement Assessment Battery for Children, Version 2 |
| PA | Physical Activity |
| p-DCD | Probable DCD |
| RER | Respiratory Exchange Ratio |
| RPE | Ratings of Perceived Exertion |
| VO ₂ peak | Peak volume of oxygen or aerobic power |

CHAPTER 1- INTRODUCTION

1.1 Introduction

Motor learning refers to the relatively permanent gains in motor skill capability associated with practice or experience that occurs over the life span (Schmidt & Lee, 1999). However, there is a condition in which children's learning and performance on everyday tasks at home, school, and play environments is challenged (Cermak et al., 2002). This condition is *developmental coordination disorder* (DCD), which refers to the difficulty in movement skills found in children that is not primarily due to general intellectual, primary sensory, or motor neurological impairment (DSM-IV, 1994; Hall, 1988). These problems make daily activities such as tying shoelaces, handwriting, and participation in physical activities such as skipping or basketball extremely difficult (Cairney et al., 2006a). Moreover, these children may suffer ridicule in the playground, an environment where their motor impairments are frequently most visible (Cairney et al., 2005b). It is not surprising that children with DCD have reported that their clumsiness contributes to negative feelings about themselves, reduced motivation to participate in physical activities, and low perceived competence in the physical domain (Losse et al., 1991).

This cohort of school-aged children represents a substantial proportion (6-10%) of the pediatric population that has an obstacle to physical activity (Bouffard et al., 1996; Cantell et al., 1994; Faught et al., 2005; Hands & Larkin,

2002; Okely et al., 2001; Ulrich, 1987). As suggested, this deficit in physical activity may not change with age (Cairney et al., 2006a; Bouffard et al., 1996).

Research conducted the past decade has provided evidence that children with DCD demonstrate a risk factor profile that mirrors that of adults with cardiovascular disease, including decreased cardiorespiratory fitness and increased body fat mainly due to decreased levels of physical activity (Barnett et al., 2008; Cairney et al., 2007a; Faught et al., 2005; Schott et al., 2007). Although the findings are consistent, these studies were restricted to field-based methods to assess cardiorespiratory fitness. Such field tests have been described as vulnerable to both motivational and environmental effects, especially for children with DCD (Armstrong & Welsman, 2001a; Cairney et al., 2006b).

There is minimal evidence underlying reasons for this low level of cardiorespiratory fitness in these children (Faught et al., 2005). The most logical explanation is the compromised ability and desire for physical activity, whether it be organized or free-play (Cairney et al., 2005b; Cairney et al., 2005c). However, a less obvious explanation may lie in the child's perceived adequacy regarding performance in physical activity (Cairney et al., 2006b; Peik et al., 2000). Children with DCD report less confidence in their physical abilities (Skinner and Peik, 2001), lower generalized self-efficacy toward physical activities (Cairney et al., 2005b) and lower levels of motivation toward attempting challenging skills than children without DCD (Rose et al., 1998). Perceived adequacy toward physical activity is likely an important factor affecting performance in aerobic testing, particularly in field tests conducted in groups (Cairney et al., 2007b;

Hands & Larkin, 2002). The Léger multistage 20 metre shuttle run is one such test that fits this description and has been adopted in much of the research on cardiorespiratory fitness in children with DCD due to its practicality in assessing aerobic fitness in large epidemiologic studies (Cairney et al., 2007a; Faught et al., 2005; Hands, 2008). Cairney and colleagues (2006b) were the first to examine the role of psychological factors in the relationship between motor coordination and cardiorespiratory fitness in children with DCD in an epidemiologic field-based study. Their findings suggested that a significant amount (34%) of the variance in cardiorespiratory fitness as assessed by the Léger 20-metre shuttle run could be explained by perceived adequacy toward physical activity in children with DCD. The proposed study is intended to partially expand on these findings in a laboratory-based setting. First, in order to gain a better understanding as to the true influence of perceived adequacy on cardiorespiratory fitness in children with DCD, a direct measure of maximal aerobic power (VO_2 peak) in a laboratory setting is essential. Currently, no published studies have adopted the gold standard of assessing VO_2 peak in children with DCD using direct spirometry.

Finally, hypoactivity among children with DCD can put their long-term health and well-being at greater risk (Cairney et al., 2005a; Cairney et al., 2007a; Faught et al., 2005; Cantell et al., 2008). More specifically, they have less opportunity to develop their muscular strength and cardiorespiratory fitness (Hands & Larkin, 2002). Considering the sedentary lifestyle reported in children

with DCD, we will also consider the influence of physical activity on cardiorespiratory fitness in this cohort.

1.2 Objective

The primary objective of this study was to examine the mediating role of physical activity and perceived adequacy toward physical activity on cardiorespiratory fitness, in children with developmental coordination disorder.

1.3 Hypothesis

We hypothesized that physical activity and perceived adequacy toward physical activity would be mediating factors in the relationship between developmental coordination disorder and cardiorespiratory fitness.

CHAPTER 2 – REVIEW OF LITERATURE

2.1 Developmental coordination disorder

For nearly a century, poor motor coordination in children has been recognized as a developmental problem (Coleman et al, 2001; Miyahara & Register, 2000). As early as 1937, these children were classified as 'clumsy', 'awkward', or 'having movement difficulties' (Orton, 1937). The introduction of the term *Developmental Coordination Disorder* (DCD) in the Manual for Mental Disorders of the American Psychiatric Association (DSM-IV, 1994) has increased awareness of this condition, forming criteria that distinguish DCD as a separate disorder from similar conditions such as apraxia or developmental dyspraxia (Missiuna & Polatajko, 1995; Miyahara & Mobs, 1995; Miyahara & Register, 2000). This section will discuss the characteristics of this condition.

2.1.1 Background

According to the DSM-IV (American Psychiatric Association, 1994) DCD is defined by the following four diagnostic criteria;

- A. Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. This may be manifested by marked delays in achieving motor milestones (e.g., walking, crawling, and sitting), dropping things, "clumsiness," poor performance in sports, or poor handwriting.
- B. The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living.

- C. The disturbance is not due to a general medical condition (e.g., cerebral palsy or muscular dystrophy) and does not meet criteria for a pervasive developmental disorder.
- D. If mental retardation is present, the motor difficulties are in excess of those usually associated with it.

The current prevalence of DCD is reported between 6% and 15% of children between 6 and 12 years of age, showing that it is a significant disorder (Barnhart et al., 2003; Henderson & Henderson 2002; Wilson, 2005). Nevertheless, some authors have argued that the DSM-IV terminology and criteria have served to focus attention on specific movement difficulties but are problematic in other respects (Wilson, 2005; Henderson & Henderson, 2002). In addition, due to the heterogeneity of DCD, it has been difficult to find its cause (Cermak et al., 2002). No convincing evidence exists to date supporting the latent pathophysiology of the various negative outcomes of DCD (Flouris et al., 2005). Generally, children's coordination difficulties can result from a combination of one or more impairments related to proprioception, motor programming, as well as timing, or sequencing of muscle activity (Barnhart et al., 2003).

DCD often not diagnosed until the child reaches school age because a particular child's lack of coordination becomes a problem when it results in failure to satisfy particular environmental demands (Cermak et al., 2002). However, there is no single tool that can be used with confidence to diagnose DCD, mainly due to terminology and criteria issues of the disorder (Hay et al., 2004). Consequently, there is a two-step process to identify children who are suspected of having DCD (Flouris, 2004), initial screening for indicators of movement

incompetence (e.g. Children Self-Perceptions of Adequacy in and Predilection for Physical Activity Scale) (Hay et al., 2004) and a confirmatory motor test (e.g. The Movement Assessment Battery for Children) (Henderson & Sugden, 1992).

Unlike other conditions that cause movement problems in children, such as cerebral palsy or muscular dystrophy, DCD is often not noticed by parents or teachers and often goes undiagnosed and receive unofficial and frequently more damaging labels such as clumsy, awkward, or lazy. Children with DCD then form a “hidden cohort” at risk of social exclusion and ridicule from other children (Cairney et al., 2005b; Cairney et al., 2006a). Additionally, approximately 65% of the original ‘clumsy’ children remain in that group during their teenage years (Sugden & Chambers, 2006). Therefore, compared to their motor-proficient peers, negative consequences may occur in DCD children. For example, perform poorly in school and leave school, risk for emotional and behavioral problems continuing into adulthood, and poor levels of physical activity leading to health problems (Cairney et al., 2006a).

It is important to recognize that DCD covers a heterogeneous group of children (Hoare, 1994; Sugden & Keogh, 1990), as not all children demonstrate the same clinical picture. However, since one criteria for a diagnostic of DCD is that it “significantly interferes with child’s daily living skills”, it is important to assess the impact of DCD on daily living skills, including gross motor skills, which are important playground activities (e.g. ball skills, running, jumping) and the consequences of these impairments (Cermak et al., 2002).

2.1.2 DCD and physical activity

There are a number of factors positively associated with physical activity in youth, including self efficacy in one's ability to overcome barriers to physical activity (Sallis et al., 2000), perceptions of physical or sport competence, having positive attitudes toward physical education, enjoying physical activity, and parent, sibling, and peer support (Sallis et al., 2000; Stuckey-Ropp & DiLorenzo, 1993). An additional determinant of physical activity among children and adolescents may be the level of mastery of the movement skills that are a foundation for the skills used in common forms of adult physical activity (Okely et al., 2001).

An early study by Rarick and McKee (1949) compared children with low motor proficiency to a group of very high motor proficiency, and found that children with lower motor capabilities were more interested in fine manipulative activities and tended to select passive activities for their after school activity. Recent research lends further support to this concept, suggesting that children with DCD are less likely to participate in activities such as organized sports and physical education class, or engage in free play pursuits than children without the disorder (Bouffard et al., 1996; Cairney et al., 2005c; Smyth & Anderson, 2000; Wrotniak et al., 2006).

There is a hypothesis linking DCD to poor perceived physical competence (Skinner & Peik, 2001) and activity-deficit (Bouffard et al., 1996; Cairney et al., 2005c). Specifically, the theory holds that children and adolescents with DCD perceive themselves to be less competent with regard to their physical abilities

than other children and as a result are less likely to participate in physical activities (Cairney et al., 2005b; Cairney et al., 2005c; Cairney et al., 2006b; Causgrove, 2000; Wrotniak et al., 2006). Subsequently, children with poor motor proficiency may choose a sedentary lifestyle to avoid movement difficulties and ridicule in the playground. This places their long-term health and well-being at greater risk (Petrolini et al., 1995; Hands & Larkin, 2002). As low levels of physical activity have been associated with higher adiposity in children (Smith & Biddle, 2008), the suspected inactivity places children and adolescents with DCD at much greater risk for excess adiposity and unhealthy weight gain (Cairney et al., 2005a). Studies examined the adiposity levels in this population have reported that children with DCD were significantly more likely to be overweight and obese than children without DCD (Cairney et al., 2005a; Hands, 2008; Hands & Larkin, 2006). Moreover, Faught et al. (2005) found that participation in physical activity is a significant mediator in the relationship between DCD and relative body fat, and cardiorespiratory fitness; both associated with many chronic diseases in adulthood (Rippe & Hess, 1998).

2.1.3 DCD and physical fitness

Physical fitness consists of cardiorespiratory fitness (CRF) along with other health and skill related fitness components such as muscular strength, endurance and flexibility (Caspersen et al., 1985). While most young children develop fitness through their daily activities while performing fundamental movements (e.g. running, skipping, jumping, climbing, cycling) DCD children are

less likely to be physically active, and consequently, the development of physical fitness, as well as motor skills, is compromised (Hands & Larkin, 2002).

Recent studies support this concern that children with DCD have compromised physical fitness levels (Cairney et al., 2007a; Hands & Larkin, 2006). Hands and Larkin (2002) suggested that the suboptimal fitness levels in these children might be explained by their inefficient motor control and mechanical inefficiency. In a previous study, Hands and Larkin (2002) also suggested that other factors, such as genetic disposition, social pressures, environmental constraints, and family values might also influence the development of fitness in children with DCD; however, there was no evidence to support these speculations.

Although several all components of physical fitness are important, the one component that is most strongly associated with health is CRF (Armstrong & Van Mechelen, 2000). Longitudinal data provide convincing case for the importance of CRF during growing years. For example, the Amsterdam Growth and Health study demonstrated that CRF measured longitudinally from 13 to 27 years of age was inversely correlated with total cholesterol (Twisk et al., 1995a; Twisk et al., 1995b).

Hands and Larkin (2006) compared children with motor learning difficulties (ages 5 to 8 years), to age and gender matched control, and found that children with motor difficulties had lower CRF. Cairney et al. (2007a) suggested that children with DCD demonstrate lower levels of CRF which persists among children with the disorder between age 9 and 14 years. Since DCD is not a

condition that children will likely outgrow (Cantell et al., 2003), the results of these studies indicate that these children might be at greater risk for low CRF during their growing years. In addition, it has been shown that boys with the condition may be especially disadvantaged in this regard as more than 70% of the boys with DCD have been found to fall into the low fitness levels (Carney et al., 2007a).

2.1.4 DCD and perceived adequacy towards physical activity

Self-efficacy refers to a judgment about one's capability to perform a task at given levels (Chase, 2001). Self-efficacy theory (Bandura, 1977) suggests that efficacy beliefs play a predictive and meditational role in one's thoughts patterns, behavior, and motivation. In other words, the theory suggests that individuals who perceive themselves as inefficacious in a particular behavior will avoid situations requiring that behavior and not make efforts to improve (Hay, 1992). Therefore, children will avoid specific activities if they believe they are not capable of handling the tasks (Chase, 2001).

Although self-efficacy measures are often concerned with single-act criteria, all these single acts reside within a single larger domain of what Bandura (1997) defined as generalized self-efficacy. For example, wide ranging experiences of failure in most physical activities may form basis for poor generalized self-efficacy toward physical activity, which provides a useful perspective mainly because the activities of children vary (Cairney et al., 2005c). Children with DCD may choose not to participate in physical activity because

they may not perceive themselves able to meet minimum performance expectations (Cairney et al., 2005c). "Perceived adequacy" defined as the perception of one's capability to achieve some acceptable standard of success, that standard influenced by self, parents, peers, teachers, and society's expectations (Hay, 1992). All those factors impinging on children's experience in physical activity will influence their perceptions of adequacy (Philips, 1984). "Predilection" refers to the likelihood that a child will select a physical, as opposed to sedentary, activity when given the choice (Hay, 1992). It is highly unlikely that children who perceive themselves as inadequate and with no predilection toward physical activity, like children with DCD, would be active. Perceived adequacy and predilection are components of generalized self-efficacy toward physical activity (Hay, 1992).

The Children's Self-perception of Adequacy in and Predilection for Physical Activity (CSAPPA) scale developed by Hay (1992) to measure self-reported generalized self-efficacy toward physical activity in children ages 8 to 16 years. Using the CSAPPA self-report scale, Cairney and colleagues (2005b) found that children with DCD had lower generalized self-efficacy toward physical activity and participated in fewer organized and recreational play activities than did children without the disorder. The CSAPPA scale assesses the degree to which children feel adequate in meeting the minimum standards to performance held by their peers and adults, and to what degree, when given the choice, they would opt for active over sedentary pursuits (Cairney et al., 2007b). Therefore, it captures the critical elements of what Bandura (1982) originally described as

generalized self-efficacy, perceived adequacy to be physically active and predilection for active over sedentary pursuits. Self-efficacy is widely regarded as a critical factor motivating behavior and behavior change (Bandura, 1982). In other words, generalized self-efficacy and perceived adequacy can account for a considerable proportion of the relationship between DCD and physical activities.

The consequences of DCD may lead to “a negative involvement cycle” (Keogh et al., 1981), which often includes discomfort and avoidance of physical activity. This cycle may in turn lead to hypoactivity and health related issues (Bouffard et al., 1996; Cairney et al., 2007a; Cantell et al., 2008; Faught et al., 2005; Hands, 2008). Further studies are needed to investigate whether physical activity and physical fitness, especially cardiorespiratory fitness, differs between children with DCD and typically develop children.

2.2 Assessment of cardiorespiratory fitness in children

Cardiorespiratory fitness, also called cardiovascular fitness or aerobic capacity, depends upon pulmonary, cardiovascular and hematological components of oxygen uptake delivery and the oxidative mechanisms of the exercising muscle (Armstrong, 1998). During exercise oxygen uptake (VO_2) increases with increasing exercise intensity up to a critical point beyond which no further increase VO_2 take place even though a person is still able to increase the exercise intensity (Armstrong & Welsman, 2001a). The point of leveling of VO_2 (a VO_2 plateau) is defined as maximal oxygen uptake (VO_{2max}), and reflects maximal aerobic power that is widely recognized as the best single indicator of a

person's cardiorespiratory fitness (Armstrong, 1998; Armstrong & Welsman, 2001a). However, it is well documented that the majority of young people can exercise to exhaustion without demonstrating a true VO_2 max plateau (Rowland & Cunningham, 1992). Therefore, the appropriate term to use with children and adolescents is peak oxygen uptake (VO_2 peak) (Armstrong & Welsman, 2001a).

It has been demonstrated that higher levels of CRF are associated with healthier cardiovascular profile in children and adolescents (Ortega, 2008). In addition, poor CRF early in life may have important consequences for the development of cardiovascular diseases (CVD) as the risks of CVD are likely to be in childhood and adolescence (Berensen et al., 1997). Therefore, it is essential to identify groups of children at greater risk for low cardiorespiratory fitness. However, accurate assessment of children's CRF requires a valid and reliable method of assessing VO_2 peak.

Since a test of VO_2 peak requires an "all out" effort, children's and adolescents' participation in research involving the determination of VO_2 peak should be through an informed willingness to cooperate rather than coercion (Armstrong & Van Mechelen, 2000). In order to obtain an "all out" effort, the rate of VO_2 is measured continuously during laboratory testing using graded exercise. Different field tests methods are also commonly used in children.

2.2.1 Laboratory-based assessments

The gold standard for measuring VO_2 peak is a laboratory assessment, which requires technical expertise, sophisticated apparatus and the subject performing incremental exercise test to exhaustion while his or her oxygen consumption is monitored (Vanhees, 2005). Both treadmills and cycle ergometers have been widely used for the determination of young people's VO_2 peak (Armstrong, 1998). The final VO_2 attained during the graded test is typically expressed as the volume of oxygen consumed per unit of time relative to body mass ($\text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ of body mass). When assessing VO_2 peak in children the final result must be interpreted in relation to chronological age, maturation, and body size (Armstrong, 1998). Treadmill engages a larger muscle mass and therefore VO_2 peak measured on treadmill is 8-10% higher than when measured using a cycle ergometer. However, a correlation of $r=0.9$ has been reported between treadmill and cycle ergometer when assessing VO_2 peak in children (Armstrong & Davis, 1981). Predicting VO_2 peak from submaximal data, usually from submaximal heart rate (e.g. Astrand Nomogram) is another approach, but this method has a low validity in predicting the performance of an individual (Malina et al., 2004).

2.2.2 Field-based assessments

The maximal and submaximal exercise tests in the laboratory are not well suited for measuring the cardiorespiratory fitness of large groups. Moreover, direct measurement of VO_2 peak is expensive both in terms of time and the cost of precise gas analysis (Heyward, 1998). Thus, a number of field tests, (e.g. the

one mile walk test and the Léger 20-metre shuttle run test) have been created to allow a feasible prediction of VO_2 peak (Léger & Lambert, 1982; McSwegin et al., 1997). These tests are practical, inexpensive, less time consuming, and easy to administer in field based settings such as schools, where a large numbers of children need to be assessed in a short period of time (Heyward, 1998).

Although each of these tests has been validated against laboratory based procedures, and all show moderate to good validity (Léger & Lambert, 1982; Léger & Gadoury, 1989; McSwegin et al., 1997), there is criticism in the literature regarding the ability of these tests to provide a valid prediction of VO_2 peak when testing children (Armstrong, 1998). Factors including practice, environmental conditions, motivation, pacing, and clothing and field surfaces, pre-tests instructions, and the context of testing, might influence field-based performance (Armstrong & Van Mechelen, 2008). For example, in epidemiologic studies involving young people, the most common test is the Léger 20-metre shuttle run test or a modification of this test (Ortega et al., 2008). The resemblance to the graded, speed incremented treadmill test used in laboratory settings, the controlled running speed, and the ability to conduct the test in small groups, have all led to the Léger 20-metre shuttle run becoming accepted as the favored field test for assessing VO_2 peak in children, particularly in schools settings. Further, the nature of the Léger 20-metre shuttle run test creates a feeling more like a fun running game and less as a test (Cairney et al., 2007b). For all these reasons, this test is widely used to estimate VO_2 peak in children.

Nevertheless, there is criticism in the literature arguing this test is masquerading as accurate measures of young people's aerobic fitness (Armstrong & Welsman, 2001a). The nature of the test requires the participants to run back and forth along a 20-metre course, by pivoting at the end of each lap to change direction. This intermittent style of running may lead to exhaustion through localized leg fatigue rather than central fatigue (Armstrong & Van Mechelen, 2008). Although this theory has not been tested, specific subsets of children with DCD, (e.g., children with static balance problems) might be in greater disadvantage in this regard.

Another reason may be due to the existence of two different methods to calculate predicted VO_2 peak (Lamb & Rogers, 2007). That is, using table of values (Ramsbottom et al., 1988) or using the regression equation provided by Léger et al. (1982) as a technique to predict VO_2 peak from the score obtained at the Léger 20-metre shuttle run test. In addition, some researchers argue that motivation and generalized self-efficacy play a significant role influencing the performance of children in this test (Cairney et al., 2007b).

It may be that high fitness, especially CRF, is directly related to improved health status in children (Armstrong & Van Mechelen, 2000). Researchers aiming to compare cardiorespiratory fitness levels between groups of young people should mind the way in which the peak aerobic power is assessed. Although field-based method have been created to overcome the issues with the laboratory protocols, with young people there is no valid substitute for a direct determination of VO_2 peak (Armstrong, 1998).

2.3 Assessment of cardiorespiratory fitness in children with DCD

As stated previously, researchers have speculated that children with DCD are at greater risk for poor physical fitness (Cairney et al., 2007a; Schott et al., 2007; Faught et al., 2005; Hands & Larkin, 2006). While all of these studies suggest that children with motor coordination problems are less aerobically fit than children without the disorder, many questions remain. Specifically, all of these studies use field-based assessment of VO_2 peak. For example, Schott et al. (2007) adopted a 6-minute run test, in which the child ran around a standard volleyball court, the number of rounds has counted, and the exact distance covered was determined and utilized to estimate VO_2 peak from a prediction equation. Their findings suggested that 10-12 year old children with moderate DCD (scores between 6th and the 15th percentile on the mABC) covered less distance compare to children without DCD. However, children with severe DCD (scored \leq 5th percentile on the mABC) surprisingly performed better than the moderate group. The use of the timed run test in children with DCD might obscure the results since those children usually are unable to pace themselves and therefore perform poorly in this test (Hands & Larkin, 2002).

The Léger 20-metre shuttle run test holds an advantage since running speed is controlled, so variation in pacing between children has less influence on the performance, especially for children with problems with sequenced movements, a problem more likely among children with DCD (Cairney et al, 2007b; Williams, 2002). However, there are aspects of the shuttle run test that might confound the measurement of fitness in children with DCD. While the

motor impairments associated with DCD are varied, fine motor impairment is the most common and unlikely to influence running ability (Visser, 2003), however anxiety about physical activity may compromise the final level achieved (Hands & Larkin, 2002). Thus, the 20-metre shuttle run test is considered vulnerable to both motivational and environmental effects (Armstrong & Welsman, 2001a). Cairney et al. (2007b) reported that children who perceive themselves to be less adequate than peers with regard to their physical abilities, and children who are more likely to select sedentary over active leisure pursuits, complete fewer stages on the Léger than children with higher levels of generalized self efficacy toward physical activity. These differences remains even after other factors known to influence the performance such as BMI, age, and gender, have taken into account. In addition to these variables, perceived adequacy, predilection, and enjoyment of physical education class explained another 9% of the variance in the Léger 20-metre shuttle run stage completed. Together, all these variables accounted for 31 % of the variation in Léger 20-metre shuttle run performance.

Therefore, children with DCD generally believe themselves to be less adequate at the task, and may give up sooner, because they believe they are simply not as good at physical tasks as other children are. In another study by Cairney et al. (2006b) it was found that a significant amount of the difference in peak VO_2 measured by the Léger 20-metre shuttle run test, between children with DCD and those without (34%) was explained by differences in perceived adequacy. However, the literature provides no data on CRF controlled for lean

body mass or evidence that a true maximum effort obtained from the participants. Such assessments can best be obtained in a laboratory setting.

It is appropriate then to use laboratory setting to examine differences in peak aerobic power between children with DCD and children without the disorder and to test the contribution of generalized self-efficacy toward physical activity to the variance of VO_2 peak in children with DCD. In a lab-based setting, it will be possible to measure factors such as maximum heart rate and respiratory exchange ratio (RER) that might help identify children who truly went to an exhaustive state from those who did not. Moreover, the perception of exertion, (e.g. Borg 6-20 rating of perceived exertion (RPE), can provide further information about their perception of exertion as a configuration of sensations: strain, aches and fatigue involving the muscles, cardiovascular and pulmonary systems (Gros Lambert & Mahon, 2006). In Borg's model, it is observed that as exercise performance increases along an intensity-dependent continuum, there are corresponding and interdependent increases in response intensities along perceptual (e.g., perceived exertion) and physiological (e.g. HR, RER, VO_2) continua, demonstrating a positive relationship (Borg, 1998).

In summary, the importance of fitness to general health and well-being is well-documented (Twisk et al., 1995); however, health specialists are increasingly concerned that children, in general, are not sufficiently active on daily basis to maintain a healthy level of fitness (Hands & Larkin, 2002). Therefore, the assessment of peak aerobic power as a direct indicator of CRF in children, particularly in children at risk for hypoactivity, such as those with DCD,

is important. Supplementary information, how peak aerobic power differs between children with DCD and typical develop children, and further clarification of the link between generalized self-efficacy and peak aerobic power using more valid and reliable methods such as in laboratory based setting, is needed.

CHAPTER 3 - METHODS

3.1 Research design

This investigation made use of data collected from the Physical Health Activity Study Team (PHAST). The PHAST is longitudinal investigation comprised of two study phases. Phase I was conducted between September 2004 and September 2007. During this phase, 2519 children from an original sample of 3030 grade four students (75 of 90 possible schools) agreed to participate in bi-annual school-based health assessments. Phase II is currently being conducted between September 2007 and June 2010 on the same cohort of students. This research phase involves an annual school-based health assessment as well as a prospective case-control laboratory assessment, which formed the design premise of this investigation. Research ethics boards at both Brock University (Appendix 1) and the District School Board of Niagara provided ethics approval.

3.2 Participants

From the original sample of 2519, 1785 students from 62 schools agreed to participate in the phase II school-based component (71% consent rate). Of these students, 963 (54% response rate) originally expressed interest in being contacted by telephone to participate in the laboratory-based component. We contacted 124 of these children by telephone (Appendix 2) previously identified in phase I with probable DCD (motor proficiency in lowest 10th percentile according to m-ABC). A total of 67 of these children (54% consent rate) agreed to

participate, including 31 females and 36 males. Healthy control subjects (n=67) matched for age (within 6 months), gender and school location were systematically selected randomly from the consenting healthy students.

Difference in cardiorespiratory fitness difference between children with DCD ($31.4 \pm 4.3 \text{ ml} \cdot \text{min}^{-1} \cdot \text{ffm}^{-1}$) and healthy control ($38 \pm 7.6 \text{ ml} \cdot \text{min}^{-1} \cdot \text{ffm}^{-1}$) subjects' as estimated from the Léger 20-metre shuttle run (Cairney et al., 2007a) was used to estimate the appropriate sample size for this investigation. Assuming a power of 80% and 0.05 level of significance, a sample size of 60 was required for each group based on unmatched case-control calculated sample estimates (<http://www.stat.ubc.ca/~rollin/stats/ssize/caco.html>). Due to incomplete data, the final sample for this study included 122 subjects (61 DCD cases, 61 healthy controls).

3.3 Procedures and measurements

Subjects were scheduled for an appointment at the Applied Physiology Laboratory of Brock University. Upon arrival, the subject and their parents were re-informed of the purpose of the study and consent/assent forms were signed (Appendix 3 and 4). The laboratory-based health assessment is multifaceted, including a large battery of physiologic and survey-based assessments. For clarity and brevity, only those assessment tools required for the purpose of this investigation are described below.

3.3.1 Body composition

All body composition assessments were performed in a private body composition room and in the presence of the child's parent(s) to ensure privacy to all subjects. Height was measured using a stadiometer (Ellard Instrumentation Ltd.) and recorded to the nearest 0.1 cm. Weight was measured using a digital scale (Tanita) and recorded to the nearest 0.1 kg. Subjects were instructed to remove their shoes and excessive clothing prior to height and weight measurements.

Relative body fat was assessed using whole body air-displacement plethysmography with the BOD POD (Life Measurement, Inc, Concord, CA) (Fields et al., 2000). The BOD POD has repeatedly demonstrated to be a reliable and valid technique in evaluating body composition in children and obese individuals (Nunez et al., 2000). The surface of clothing and hair has a significant impact on volume measurements. Therefore, all subjects wore tight fitting swimsuits or spandex shorts and a Lycra swim cap. Prior to the assessment, subjects were instructed on the importance to avoid any movement, to relax and breathe normally while inside the chamber. Body volume was measured twice; each session lasting approximately 40 seconds. If the results of the two trials were not within 150 ml, a third trial was performed with the average of the two closest trials being accepted.

3.3.2 Peak aerobic power

Peak aerobic power (VO_2 peak) was measured on a programmed cycle ergometer (Excalibur Sport V2, Lode BV, Groningen, Netherlands), using a continuous, and incremental exercise protocol. Prior to the assessment, subjects were instructed as to the expected physical exertion associated with this evaluation and the importance of exercising until they have reached maximum volitional fatigue. The saddle, handle and pedals of the cycle ergometer were adjusted to give optimal comfort and efficiency for the subject while peddling. The subject's feet were strapped to the pedals to prevent them from slipping. Each subject had a practice period on the cycle ergometer as well as the opportunity to insert the mouthpiece and nose clips with the intent of familiarizing themselves with the equipment. Metabolic gases were analyzed using an AEI metabolic cart (Model S-3A, AIE Technologies, Pittsburgh, Pennsylvania). Heart rate was recorded continuously during the assessment using a Polar heart rate monitor.

Subjects began cycling at a cycling rate of 70 to 75 rpm. Initial power output was set at 20 Watts for the first three minutes. After this warm-up period, work rate was increased to 40 Watts for the forth minute, beyond which it was increased by 20 Watt every minute until the final stages. During the estimated final stages, 15 Watt increments were used until volitional fatigue. All subjects were verbally encouraged throughout the assessment. Subjects were instructed to rate their perceived exertion using a standardized Borg rating of perceived exertion (RPE) (Appendix 5) scale from 6 (very, very light) to 20 (very, very hard) at the end of exercise (Borg, 1998). The criteria used to verify the achievement of

peak aerobic power were two of the following: a respiratory gas exchange ratio of at least 1.00, heart rate >85% of age-predicted, or signs of intense effort (e.g. hyperpnoea, facial flushing, or difficulties in keeping up the speed of the cycle), (Armstrong, & Van Mechelen, 2000). For comparison of differences between the groups, VO₂ peak was adjusted for body size (body mass in kilograms) and fat free mass (FFM) (Dencker et al., 2007).

3.3.3 Developmental motor coordination

The Movement Assessment Battery for Children, 2nd Edition (mABC-2) was used as a motor competence test, assessing both gross and fine motor coordination (Henderson, Sugden & Barnett, 2007) (Appendix 6). It is the most frequently used standardized motor test to screen for identifying children with DCD in research (Wilson, 2005) and is well known for a high standard of reliability and validity (Crawford et al., 2001; Tan et al., 2001). The test consists of eight tasks (items) which are grouped under three headings: Manual Dexterity, Aiming & Catching and Balance. For each item, a standard score was provided. From each of these standard scores, a cumulative score (age adjusted) and percentiles are provided (Henderson, Sugden & Barnett, 2007). Children with a score at or below the 10th percentile were identified as DCD. All tests were administrated by a pediatric occupational therapist that was familiar with the procedures of the mABC-2. However, full assessment of all DSM-IV (1994) (see chapter 2, section 2.1.1) criteria is required to confirm a diagnosis of DCD. For the current study the

information for meeting criteria B of DSM-IV (1994) is missing, therefore we used the term probable DCD (p-DCD) to address this limitation.

3.3.4 Perception of adequacy in physical activity

The students enrolled in the PHAST school assessments study that had been previously completed three to six months prior to the laboratory assessment were accessible. Children completed the Children's Self-perceptions of Adequacy in and Predilection for Physical Activity (CSAPPA) scale (Appendix 7) in the student's regular classroom (Hay, 1992). Research assistants explained the questionnaires, facilitated the students and evaluated the completeness of each questionnaire. No time limits were set on the students to complete the questionnaires. When completing the CSAPPA scale, children were asked questions concerning self-perceptions of their adequacy in performing, and desire to participate in, physical activities. The questions are structured in an alternative choice format presenting descriptions of physical activities. Higher scores indicate positive self-perceptions. The total score was calculated as well as subtotals for reporting adequacy, predilection toward physical activity, and enjoyment of physical education class (Hay, 1992). The precision for this test as well as the predictive and construct validity have been previously reported (Hay, 1992; Hay et al., 2004).

The factor measuring perceived adequacy has strong test-retest reliability ($r=0.84$ for grade 7 students), has demonstrated strong factorial consistency between cohorts and genders, and is significantly correlated to participation in

organized sports and teachers' evaluations of physical activity (Cairney et al., 2007c; Hay, 1992). Moreover, this subscale of the CSAPPA was found in previous work as a significant mediator between DCD and VO₂ peak (Cairney et al., 2006b), therefore perceived adequacy was chosen to use as psychological factor to predict VO₂ peak.

3.3.5 Pubertal maturity

To ensure proper classification of subjects into their age/maturation grouping, pubertal maturity was self-assessed using the appropriate Tanner staging pictures (Appendix 8) (Taylor et al., 2001). To reduce embarrassment, subjects completed the self-assessment at home in the presence of a parent. Once completed, the self-assessment placed in a plain folder by the subject and returned directly to the researcher assistant in order to maintain anonymity.

3.3.6 Physical activity

Actical activity monitors have been established as a valid measure of children's step-count and activity counts, and can be used to determine levels of physical activity (Esliger et al., 2007; Esliger & Tremblay, 2007; Puyau et al., 2004). Children were fitted with the Actical activity-monitoring device (Actical, version 2.0, Mini Mitter, Respironics) to wear for a 7-day period following their visit to Brock University. The unit on the belt was positioned on the hip at the mid-axilla line, which has been proven the most accurate placement (Nilsson et al., 2002; Ward et al., 2005). Parents were provided with a log to record the time within

each day that their child had removed/replaced the unit for bathing, swimming, and bedtime (Appendix 9). The monitor was collected from the child's home 7 days following the lab visit. Seven day sampling been shown to be the most valid estimate of a child's habitual physical activity (Trost, 2001).

Data downloaded to a university computer and the accelerometer unit was re-formatted for the next subject. All units were programmed individually for name, age, gender, height, and weight. The Actical uses an omni-directional sensor with sensitivity to motion in all directions. This type of sensor integrates the amplitude and frequency of motion and produces an electrical current that varies in magnitude (Actical Instruction Manual, 2006). Therefore, an increased intensity of motion produces an increase in voltage. Actical stores this information in the form of activity counts. Activity was recorded in 30-second epochs for total daily activity counts for each day. Recent review by Reilly et al (2008) suggested that despite a widespread perception that epoch shorter than 1 minute are essential to measure physical activity in children; the empirical evidence on the topic is limited and does not support the notion that "short" epochs are essential. For the purpose of our study we felt that 30 sec epochs would be sufficient to capture the activity patterns of our subjects.

3.4 Statistical analyses

All statistical analyses performed using SPSS (version 16). Descriptive statistics where calculated including mean, standard deviation and range for subject age, maturation level, relative body fat, all exercise test variables, physical activity

level and perceived adequacy. One-way analysis of variance (ANOVA) was used to compare differences between children with DCD and control group for all anthropometric and physiologic variable characteristics. A Chi square analysis was used to compare the pubertal stage distributions. In order to test the hypothesis of the study, whether the differences in VO_2 peak between children with DCD and without DCD are mediated by perceived adequacy and physical activity, we used linear regression analysis. Three regression models were tested (Figure 3.1). Using a technique of progressive adjustment, we examined the main effect of DCD on VO_2 peak_{FFM} (Model 1) and if the relationship between DCD and VO_2 peak can be explained by a change in the unstandardized *b*-coefficient for DCD when perceived adequacy (Model 2) and physical activity (Model 3) are entered to the model (Figure 3.1). More specifically, a reduction in the *b*-coefficient would support the prediction that DCD leads to lower perceived adequacy and less physical activity, which in turn leads to a lower VO_2 peak. In all models, we controlled for age and gender. In the event of multi-collinearity (variance inflation factor >10), independent variables were zeroed. Level of significance for all analytic analysis was set at $\alpha=0.05$.

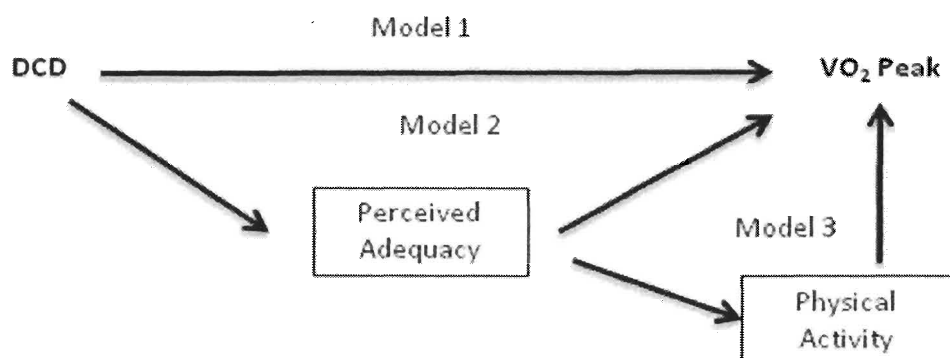


Figure 3.1 Illustration of the regression models

CHAPTER 4 - RESULTS

4.1 Sample characteristics

This study was part of a larger laboratory-based prospective case-control design examining the cardiovascular health of children with p-DCD and matched controls. A sample of 122 subjects, including 61 children with p-DCD and 61 controls matched for age, gender and school were initially included in this study. Table 4.1 shows the anthropometrical characteristics for the p-DCD and control groups. Children with p-DCD had significantly higher body mass and percent body fat compared to children without the disorder. There were no differences in maturation stage between the two groups. The two groups were similar in terms of pubertal stage distribution. Within the controls the number of children in each pubertal stage was: 4 in stage I, 21 in stage II, 16 in stage III, 14 in stage IV and 6 in stage V. Within the p-DCD the distribution was: 3 in stage I, 13 in stage II, 20 in stage III, 17 in stage IV and 5 in stage V.

Table 4.1 Anthropometric characteristics (mean±sd)

| | Entire Sample | Control | p-DCD |
|--------------------|---------------|-----------|-----------|
| Number of Subjects | 122 | 61 | 61 |
| Males | 72 | 36 | 36 |
| Females | 50 | 25 | 25 |
| Age (years) | 12.9±0.41 | 12.8±0.38 | 12.9±0.44 |
| Mass (kg) * | 54.7±15.5 | 50.2±11.5 | 59.1±17.7 |
| Height(cm) | 157.6±7.8 | 156.9±7.8 | 158.4±7.7 |
| Body Fat (%) * | 24.02±11.2 | 20.0±9.9 | 28.0±11.1 |

Note: * = values significantly different ($p<0.05$) between p-DCD and Control.

4.2 Physiologic characteristics for VO_2 peak assessment

Table 4.2 presents the physiologic characteristics of the peak aerobic power assessment. VO_2 peak was significantly lower ($p<0.05$) in the p-DCD group, even when maximal aerobic power was normalized to fat free mass (Table 4.2). There were no significant differences in maximum heart rates between groups. Children with p-DCD had similar rate of perceived exertion values as children without p-DCD.

Table 4.2 Physiologic characteristics for VO₂ peak assessment (mean±sd)

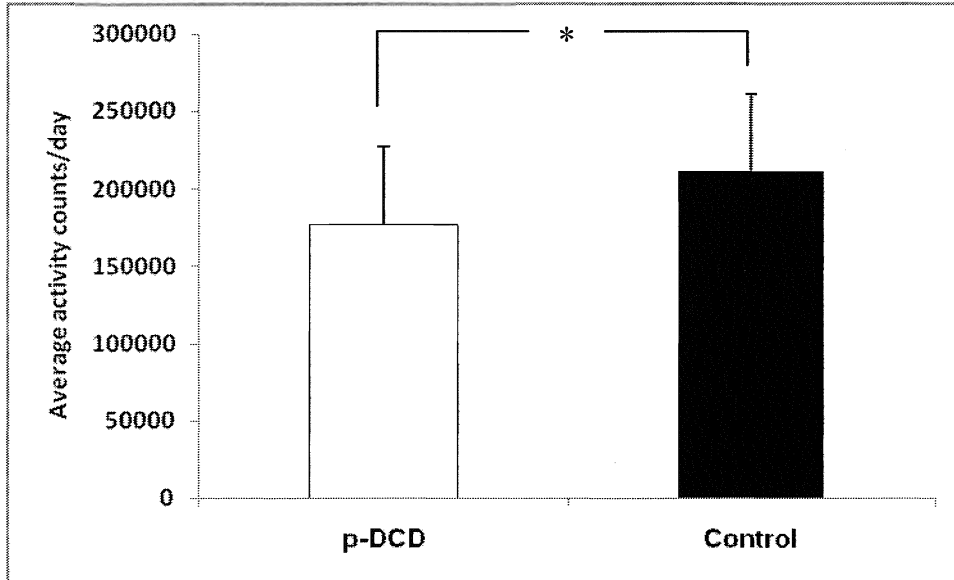
| | Entire Sample | Control | p-DCD |
|--|---------------|------------|------------|
| Peak VO ₂ * (ml·kg ⁻¹ ·min ⁻¹) | 38.96±8.8 | 42.91±8.1 | 35.01±7.6 |
| Peak VO ₂ * (ml·ffm in kg ⁻¹ ·min ⁻¹) | 50.94±8.0 | 53.12±8.2 | 48.76±7.2 |
| Maximum HR (beats·min ⁻¹) | 189.8±13.5 | 191.6±12.6 | 187.9±14.3 |
| Final RER* | 1.07±0.09 | 1.1±0.09 | 1.05±0.09 |
| Final RPE | 16.9±1.7 | 16.9±1.5 | 16.8±2.0 |

Note: * = values significantly different ($p<0.05$) between p-DCD and Control.

4.3 Physical activity and perceived adequacy

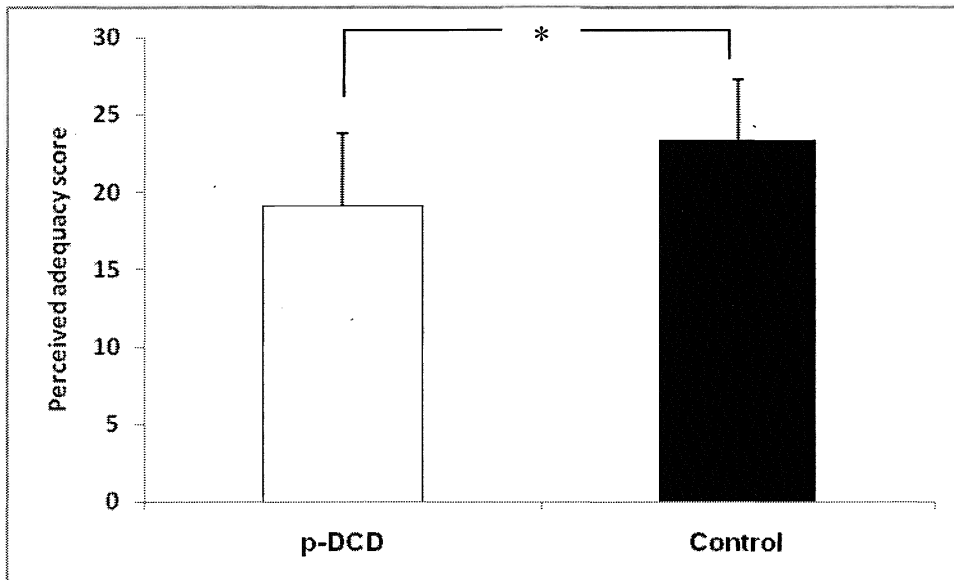
We adopted accelerometer inclusion criteria based on previous studies (Tudor-Locke & Myers, 2001; Hands et al. 2004; Trost et al., 2005; Wrotniak et al., 2006). Based on these criteria, data was excluded if the subject wore the accelerometer; 1) less than 600 minutes (10 hours) per day, 2) less than 1000 or more than 40000 steps per day, and/or 3) less than 5 days over a 7-day period. Thus, 58 (92%) controls and 54 (86%) p-DCD were included in the analysis of physical activity data. There were no differences between the two groups in terms of number of days that the accelerometers were worn during the seven days period, and in the total time that the accelerometers were worn per day. Figure 4.1 presents weekly physical activity as activity counts per day. Children with p-DCD were significantly less active than children without the condition.

Figure 4.2 describes the mean scores of perceived adequacy toward physical activity. Significant differences ($p < 0.05$) were detected in perceived adequacy between the two groups.



Note: * = values significantly different ($p < 0.05$) between p-DCD and Control.

Figure 4.1 Weekly physical activity counts by group



Note: * = values significantly different ($p < 0.05$) between p-DCD and Control.

Figure 4.2 Mean scores for perceived adequacy by group

4.4 Regression analysis

Table 4.3 reports the results of the regression analysis. We chose to use the VO_2 peak per FFM (VO_{2FFM} peak) as the outcome variable in order to control for the differences that was found in percent body fat between children with p-DCD and those without. In Model 1, the main effect of p-DCD on VO_{2FFM} peak was negative and significant after adjusting for gender and age. Once perceived adequacy is entered in Model 2, the unstandardized b -coefficient for p-DCD reduced by 29%. Together, these variables account for 17.5% of the variance in VO_{2FFM} peak.

In Model 3, with physical activity entered, r -squared was increased by 7%. Physical activity is significantly associated with higher VO_{2FFM} peak ($p < 0.05$) and once entered to the model the unstandardized b -coefficient for p-DCD is reduced by 16%. In Model 4, we tested to see whether the effect of p-DCD on VO_{2FFM} peak is different for boys and girls, and whether any differential gender effects on VO_{2FFM} peak are attributed to differential effect of gender on perceived adequacy and physical activity. The results indicate no significant differences by gender (Table 4.3).

Table 4.3 Regression of VO_{2FFM} peak on p-DCD, perceived adequacy and physical activity

| Variables | Model 1 | Model 2 | Model 3 | Model 4 |
|--------------------------|------------------|-----------------|-------------------|-----------------|
| p-DCD | -4.448** (1.349) | -3.149* (1.581) | -2.639 (1.571) | -2.912 (2.568) |
| Age | 0.970 (1.716) | 2.213 (1.945) | 1.101 (1.891) | 1.010 (1.916) |
| Gender | 4.726** (1.430) | 2.937 (1.580) | 2.667 (1.536) | -0.555 (9.156) |
| Adequacy | | 0.348* (0.174) | 0.316 (0.169) | 0.364 (0.281) |
| Physical Activity | | | 2.34E-5* (1.0E-5) | 8.7E-6 (1.0E-6) |
| Gender*p-DCD | | | | 1.276 (3.349) |
| Gender*Adequacy | | | | -0.106 (0.347) |
| Gender*Physical Activity | | | | 2.57E-5 (0.00) |
| Constant | 37.86 | 15.06 | 25.24 | 28.45 |
| <i>R-squared</i> | 0.170 | 0.175 | 0.243 | 0.254 |

Unstandardized *b*-coefficients are reported with Betas in parentheses.

Note: **p*<0.05; ***p*<0.001

CHAPTER 5 – DISCUSSION

5.1 Introduction

The objectives of this investigation were to compare VO_2 peak between children with and without significant motor impairments, and to examine the contribution of perceived adequacy and physical activity to the variance in VO_2 peak. In order to fulfil these aims, children's motor competence (e.g., mABC), peak aerobic power, perceived adequacy (CSAPPA) and physical activity were evaluated. A total of 122 children were assessed: 61 cases (children with p-DCD) and 61 controls (children without p-DCD). We hypothesised that perceived adequacy and physical activity would be mediator factors in the relationship between DCD and VO_2 peak.

5.2 Differences in peak aerobic power

This is the first study of children with significant motor impairment performing assessment of peak aerobic power in the laboratory, as a direct indicator of cardiorespiratory fitness. The results demonstrated that children with poor coordination have lower levels of VO_2 peak compare to children without the disorder. Since age and maturation might be confounding factors when measuring VO_2 peak in children (Kemper, 2004; Armstrong & Welsman, 2001b), we classified each subject into their age and maturation grouping and found that there were no differences between the two groups in these variables.

Although the assessment of adiposity was not one of the objectives of the current study, this is the first study that used whole body air-displacement plethysmography to assess percent body fat in children with p-DCD. The results are as compelling as other studies (Cairney et al, 2005a; Faught et al., 2005; Hands, 2008; Hands & Larkin, 2006; Cantell et al., 2008) indicating that children with movements difficulties are in greater risk for obesity.

If using the conventional scaling of oxygen uptake per unit of body mass when measuring peak aerobic power, body fat might be a confounder factor (Armstrong, & Van Mechelen, 2000). Since our sample showed that children with p-DCD had significantly higher levels of percent body fat, we chose to display the results also as per kg of fat free mass (FFM) (Dencker et al, 2006). The results demonstrated the same pattern, meaning children with motor impairments remained unfit compared to their coordinated peers, regardless to their elevated percent body fat.

The results of the current study confirm previous report that children with DCD are in greater risk for lower levels of cardiorespiratory fitness compare to normal developed children (Cairney et al., 2007a; Faught et al., 2005; Hands & Larkin, 2006, Schott et al., 2007). These studies relied only on common field tests (e.g. the Léger 20-metre shuttle run test or distance/timed run tests) which are generally criticised in the literature regarding their ability to provide a valid prediction of VO_2 peak when testing children (Armstrong, 1998). Schott et al (2007) used the 6-min run test, however their results might be affected since clumsy children usually are unable to pace themselves and therefore perform

poorly in this test (Hands & Larkin, 2002). The Léger 20-metre shuttle run test holds an advantage since running speed is controlled, so variation in pacing between children has less influence on the performance, especially for children who have problems with sequenced movements, a problem most likely among children with motor impairments (Cairney et al., 2007b; Williams, 2002). However, the Léger 20-metre shuttle run test is vulnerable to both motivational and environmental effects due to its competitive nature that might influence the results, especially in children with DCD (Armstrong & Welsman, 2001a, Cairney et al., 2007b, Cairney et al., 2006b). Given the reported low perceptions of athletic competence, the low levels of peer acceptance, (Cairney et al., 2005b; Cantell., 1994) and the fact that children with DCD report greater anxiety than peers without disabilities when faced with movement situations (Rose et al., 1991; Skinner & Piek, 2001) it is not surprising that children with p-DCD perform poorly on field tests. Moreover, these studies failed to provide evidence that a true maximum effort obtained from the participants (Cairney et al., 2007a; Faught et al., 2005; Hands & Larkin, 2006, Schott et al., 2007).

The present study was the first to report the use of controlled environment (e.g. laboratory setting) when assessing VO_2 peak in children with significant motor impairments. Since these children may suffer ridicule in the playground, an environment where their motor impairments are frequently most visible (Cairney et al., 2005b), it seems reasonable to choose lab-based setting in order to establish more accurate determination of their cardiorespiratory fitness. There is nothing suggesting that similar results may not be found in the laboratory, and

that the individual interactions between the tester and the child might allow psychological factors to assume an even greater role in performance (Cairney et al., 2007b). However, the laboratory setting allowed us to measure factors (e.g., max HR and RER) that helped to identify children who truly went to an exhaustive state (Armstrong, & Van Mechelen, 2000). The results showed that in term of maximum heart rate, there were no significant differences between children with p-DCD and their normal developed peers; both groups exhibited values above 188 (beats·min⁻¹). Respiratory exchange ratio values were above 1.05, meaning both groups went to an exhaustive stage (Armstrong, & Van Mechelen, 2000; Dencker et al, 2006). Furthermore, there were no differences in rate of perceived exertion between the two groups (e.g., RPE=17), meaning that the last stage perceived very hard for both children with p-DCD and for those without. Since there is no data available concerning the amount of effort that children with DCD demonstrated in aerobic fitness tests we cannot compare our results to other studies. However, the hypothesis that children who doubt their capabilities at a task and have low perceived adequacy (like children with DCD), are not likely to persist when so much attention is focused on their performance, was not supported by our results. It is possible that in the current study the tester's strategies to encourage the children, moving from challenge to support by external feedbacks and verbal persuasion, enhanced their performance on the test. The use of these strategies proved in the past to enhance self-efficacy toward physical activity in children (Wright et al., 2005).

5.3 Differences in perceived adequacy and physical activity

The result of this study support earlier findings suggesting that children with p-DCD report lower perceived adequacy, measured by the CSAPPA (Hay & Missiuna, 1998, Cairney et al., 2007c). Similar to other work, our results showed that children with p-DCD not only perceive themselves to be less competent in basic physical skills (Piek et al., 2000; Skinner & Piek, 2001), but also perceive themselves to be less adequate in their overall physical abilities (Cairney et al., 2005c; Hay et al., 2004; Hay, 1992).

Over a period of seven days the results suggested that children with p-DCD are less active compare to children without the condition as measured by Actical activity monitors. The results are in line with recent research supporting the concept that children with motor impairments are less likely to participate in physical activities (Bouffard et al., 1996; Cairney et al., 2005c; Smyth & Anderson, 2000; Wrotniak et al., 2006). Most of these studies used subjective measures to assess physical activity (e.g., self-report questionnaires). There is only one study that used an objective measure, and as in our findings, found that motor proficiency is positively associated with physical activity in children (Wrotniak et al., 2006).

5.4 The mediating role of perceived adequacy and physical activity

The question remains: why do children with significant motor impairments have lower VO_2 peak compared to their peers? We used perceived adequacy and physical activity, which both found to be lower in our sample of children with p-

DCD, in order to have a better understanding of the contribution of these variables to the differences in cardiorespiratory fitness between the two groups.

The need to consider psychological variables in the interpretation of aerobic tests results has been suggested by Cairney et al (2007b). They reported that perceived adequacy was significantly associated with stage completed in the Léger 20-metre shuttle run test. In another study, the competitive and social nature of the test, when coupled with perceptions of poor general physical ability, was also found to negatively affect the results of children with DCD (grade 4 through 8) (Cairney et al., 2006b). A significant amount of the differences in VO_2 peak (34%) as measured by the Léger 20-metre shuttle run test between children with DCD and those without was explained by differences in perceived adequacy. Using the same model, our results showed that perceived adequacy explained 29% of the differences in VO_2 peak, suggesting that in a controlled environment, perceived adequacy toward physical activity may have less contribution to the variance in VO_{2peak} between the two groups. Since direct measurement of VO_2 peak is not feasible for use in field-based settings, and it is critical to assess whether or not DCD children truly are at greater risk for poorer aerobic fitness, the results of this study suggested that when testing children with DCD in the field we should address the psychological barriers associated with their condition.

There is evidence suggesting a positive relationship between physical activity and cardiorespiratory fitness in children (Boreham et al., 1997; Dencker et al., 2006; Klentrou et al., 2003). Since it is strongly evident that children with

motor coordination difficulties are less physically active compare to those without difficulties (Bouffard et al., 1996; Cairney et al., 2005c; Causgrove-Dunn & Romanow, 1996; Haga, 2008; Hay et al., 2004; Hay & Missiuna, 1998; Poulsen et al., 2008; Schott, et al., 2007; Smyth & Anderson, 2000; Wrotniak et al., 2006), it was reasonable to test the effect of physical activity on the variance in VO_2 peak between the two groups. The regression analysis showed that physical activity is a significant contributor to these differences, and together with perceived adequacy account for 25% of the total variance in VO_2 peak. Faught et al. (2005) found the same trend, suggesting that inactive lifestyle is a significant mediator in the relationship between DCD and cardiorespiratory fitness. However, these results were demonstrated using a field-based method to assess cardiorespiratory fitness and a subjective method to assess physical activity. Whether the remaining effect on VO_2 peak can account for other negative consequences of DCD (e.g., poor movement patterns resulting in higher energy expenditure and higher levels of fatigue) remains untested. In addition, there are a number of factors that influence VO_2 peak, such as cardiac output, oxygen carrying capacity of the blood, and perhaps peripheral diffusion gradients (Basset and Howley, 2000). Further, genetic factors modify all of this (Bouchard et al., 1986). Nevertheless, even if physical activity is only one of the factors linked to poor cardiorespiratory fitness in children with DCD, a factor can be promoted as a positive influence in intervention programs.

5.5 Limitations and recommendations

The use of a treadmill when measuring VO_2 peak in children can be a disadvantage due to a lack of familiarization leading to potentially tripping (Malina et al., 2004). In order to reduce the concern of our subjects to master the technique of treadmill walking and running, we chose to use the cycle ergometer to test for VO_2 peak. Although we believe that we minimized the amount of motor competence required as well as risk of injury from falling, research into specific subtypes of DCD that may influence assessment performance (e.g., children with gross or fine motor impairments) is needed. Furthermore, biomechanical assessment of movement was not considered during the VO_2 peak assessment. Again, the degree of motor impairment and overall economy of movement during the cycle ergometer assessment could influence performance. The reduced movement efficiency might contribute to increased energy demands in early stages of the test and to a poor test outcome even though the uncoordinated child may be working as hard as a coordinated child may. Currently there is no evidence in the literature about the mechanical efficiency during cycling in children with DCD. However, there is evidence suggesting that poor motor proficiency related to reduced anaerobic power as measured by the 30 seconds Wingate Anaerobic Test performed on bicycle ergometer (O'beirne et al., 1994). O'beirne et al (1994) also found that children with poor motor ability were not able to maintain as great a percentage of their peak power for the entire test. This was evident by higher scores in fatigue index, which showed increased fatigue by this group.

From a neuromuscular perspective, there is some evidence in the literature suggesting that children with DCD have increased levels of co-activation during isometric knee flexion and isokinetic extension (Raynor, 2001). Raynor (2001) suggested that higher levels of co-activation represent a less effective method of muscular activation and a different muscle organization compared to the normal developed children. Increased co-activation levels are just one indicator of motor coordination problems and highlight the need for further investigation in to the neuromuscular organization of children with DCD.

In another view, numerous studies have also shown that children and adolescents with DCD report greater anxiety than those without disabilities when faced with movement situations (Skinner & Piek, 2001). Anxiety about the task may have complicated the interpretation of heart rate responses. It may be that the uncoordinated children reached maximum heart rates after a shorter time and were unable to sustain the task, which may have compromised the final level achieved by the children with DCD.

Another limitation is that full assessment of all DSM-IV (1994) criteria to confirm a diagnosis of DCD is not completed. We could not confirm that the disturbance in criterion A, that the performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence, significantly interferes with academic achievement or activities of daily living.

5.6 Conclusions and implications

In conclusion, the results of this laboratory-based investigation are in line with previous field-based studies that, children with motor impairments have lower cardiorespiratory fitness compare to healthy developed children regardless of the method being used (Cairney et al., 2007a; Faught et al., 2005; Hands & Larkin, 2006, Schott et al., 2007). Since children with DCD are seldom recognized or diagnosed, their problems are ineffectively managed (Hay et al., 2004). The presence of lower cardiorespiratory fitness as found in the current study, is of particular concern because if DCD is not a condition that children likely to outgrow (Bouffard et al., 1996), it suggests that these children may be in greater risk for poor cardiovascular health (Armstrong & Van Mechelen, 2008).

Furthermore, our results showed that physical activity is a significant contributor to these differences, and together with perceived adequacy account for 25% of the total variance in VO_2 peak. Although further research is required in order to have a better understanding of the relative contribution of perceived adequacy and physical activity to the differences in cardiorespiratory fitness between children with DCD and children without the condition, there are several implications to the results of this study. First, when testing for cardiorespiratory fitness in this population there is a need to consider psychological aspects. External feedbacks and verbal persuasion may enhance their performance on the test resulting in a truer assessment of their fitness level. Second, when planning intervention programs in children with DCD cardiorespiratory fitness should not be ignored. Strategies to increase physical activity in this population

may result in improvement in their fitness level. It is important for parents and teachers of children with DCD to emphasize daily physical activity in order to improve the risk factor profile for cardiovascular disease.

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- Wrotniak, B.H., Epstein, L.H., Dorn, J.M., Jones, K.E., Kondilis, V.A. (2006). The relationship between motor proficiency and physical activity in children. *Pediatrics*, 118: 1758 – 1765.

APPENDICES

APPENDIX 1 – REB Letter of Approval

DATE: January 10, 2008

FROM: Michelle McGinn, Chair
Research Ethics Board (REB)

TO: Brent FAUGHT, CHSC
John Hay, John Cairney

FILE: 07-106 FAUGHT

TITLE: Establishing the Health Profile of Children with Motor Coordination Challenges

The Brock University Research Ethics Board has reviewed the above research proposal.

DECISION: Accepted as clarified

This project has received ethics clearance for the period of January 10, 2008 to December 30, 2011 subject to full REB ratification at the Research Ethics Board's next scheduled meeting. The clearance period may be extended upon request. *The study may now proceed.*

Please note that the Research Ethics Board (REB) requires that you adhere to the protocol as last reviewed and cleared by the REB. During the course of research no deviations from, or changes to, the protocol, recruitment, or consent form may be initiated without prior written clearance from the REB. The Board must provide clearance for any modifications before they can be implemented. If you wish to modify your research project, please refer to <http://www.brocku.ca/researchservices/forms> to complete the appropriate form Revision or Modification to an Ongoing Application.

Adverse or unexpected events must be reported to the REB as soon as possible with an indication of how these events affect, in the view of the Principal Investigator, the safety of the participants and the continuation of the protocol.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research protocols.

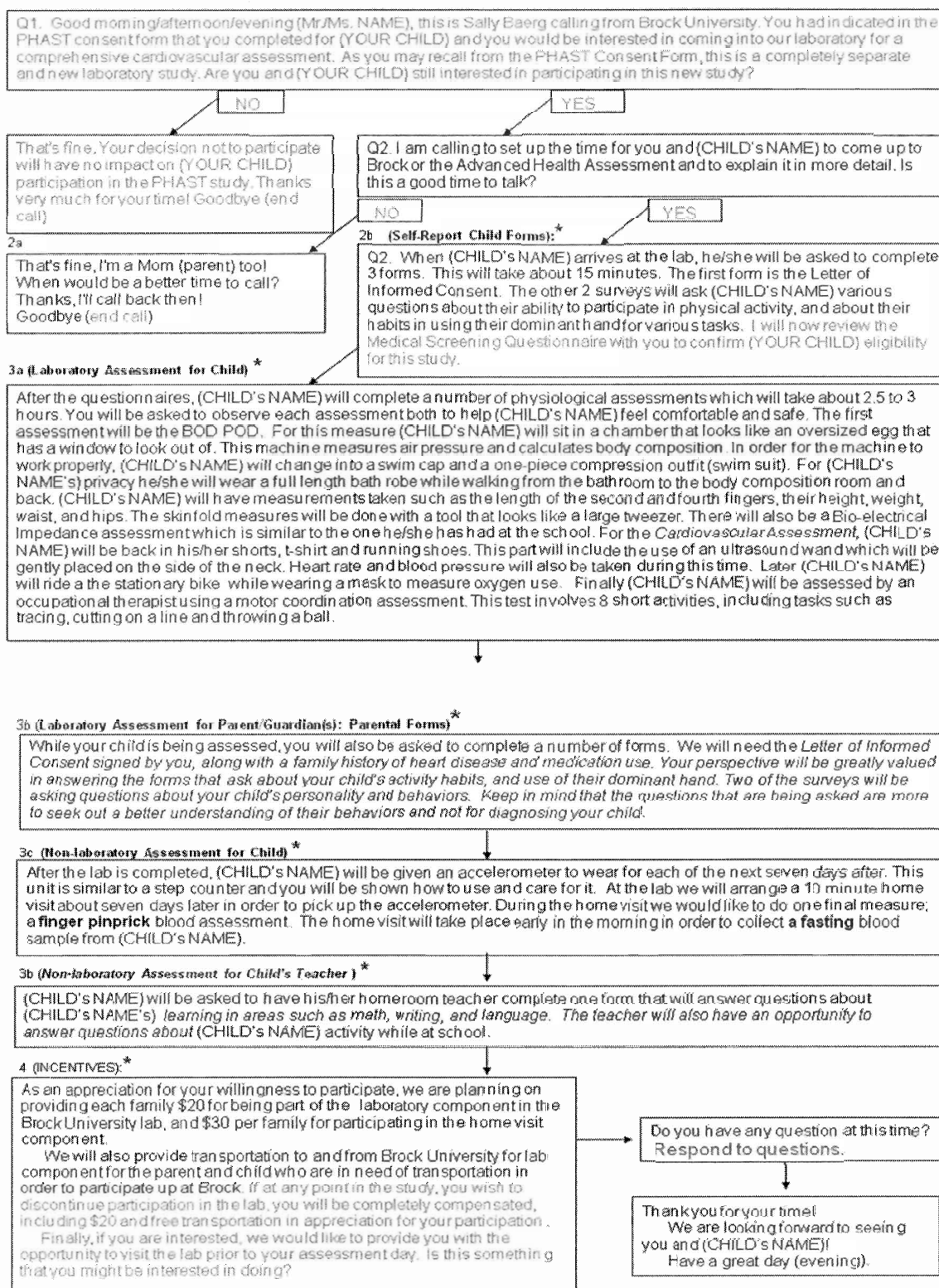
The Tri-Council Policy Statement requires that ongoing research be monitored. A Final Report is required for all projects upon completion of the project. Researchers with projects lasting more than one year are required to submit a Continuing Review Report annually. The Office of Research Services will contact you when this form *Continuing Review/Final Report* is required.

Please quote your REB file number on all future correspondence.

MM/kw

Office of Research Ethics, MC D250A
Brock University
Office of Research Services
500 Glenridge Avenue
St. Catharines, Ontario, Canada L2S 3A1
phone: (905)688-5550, ext. 3035 fax: (905)688-0748
email: reb@brocku.ca
<http://www.brocku.ca/researchservices/ethics/humanethics/>

APPENDIX 2 – PHAST Telephone Script for Laboratory Assessment



* Note: indicates that each section will end with a chance for parents to ask questions. Order of script may not play out in this particular order.

APPENDIX 3 – Child Letter of Informed Assent

Principal Investigators: Dr. John A. Hay, Brock University
Dr. John Cairney, University of Toronto and Brock University
Dr. Brent E. Faught, Brock University

Dear Parent and Child:

Thank you for your interest in our study. Please read the following information together. If you both feel comfortable and willing to participate in the tests described below, please check the boxes at the end of this consent form indicating child assent and parent consent.

Purpose: The purpose of this study is to look at healthy growth and development of children for the next three years.

Procedures: This assessment will take approximately 2.5 to 3 hours long and is divided into three parts. We thank you for participating. As promised, we have agreed to provide transportation for you to and from Brock University as well as \$50 for your family's participation in this study. Your participation is voluntary and you are free to withdraw from this study at any time without penalty from Brock University. Further, you are under no obligation to answer any or all questions or to participate in any aspect of this project. If you wish to stop participating in this study at any time, you and your parent will still receive free transportation from us as well as \$50 for your participation in the laboratory. Each part is described below.

PART I

This part of the study will be conducted in our laboratory at Brock University and requires 2.5 to 3 hours of your time. First, we would like you to complete the following forms, which will take about 10 minutes.

1. Medical Screening Questionnaire
2. Edinburgh Survey – Handedness Questionnaire

Next, we would like to complete a number of physical assessments on your child with the parent/guardian present. These assessments include:

1. **Body composition:**
 - a. Height and weight will be measured using a dual-purpose stadiometer.
 - b. 9 skinfold sites using painless pinch calipers. (It does not hurt).
 - c. Measure around the waist and hip using a flexible tape measure.
 - d. Bioelectric impedance analysis requires your child to stand on a weight scale and grasp handles. An electrical impulse travels from your child's hands to their feet. The impulse cannot be felt and causes no harm.
 - e. Lengths of your child's ring and index fingers.
 - f. Body muscle and fat weight will be measured while your child sits in the BOD POD chamber. If your child expressing previous or current anxiety for confined spaces, they will not be allowed to participate in this portion of the study. The BOD POD incorporates a built in window on the front of the chamber in the event of a claustrophobic event or for communication purposes as well as a safety latch on the inside of the chamber for the subject to voluntarily exit on their own. During this 5-minute assessment, your child will be asked to relax and breathe normally.
2. **Cardiovascular health measures:** The carotid ultrasound method will be performed using a probe and pen like-devices. Heart rate will be measured using sensors placed on the skin of your child's chest. These sensors are used to detect the electrical activity generated by the heart and are not used to transmit electrical signals into their body from the heart rate monitor. Blood pressure is monitored using an automated arm cuff system that is similar to the method used in a doctor's office. A cuff is wrapped around the upper arm and is inflated then deflated. No risk is involved.

3. **Movement ABC² assessment:** This motor coordination assessment involving 8 short activities, including tasks such as tracing, cutting on a line and throwing a ball.
4. **Physical fitness assessment:** This assessment uses a bicycle to measure the maximum amount of heavy exercise. The bicycle tension will gradually get more difficult to pedal. A mask over the mouth and nose will be used to collect oxygen and carbon dioxide. The assessment will be finished when your child decides. One of the common risks of these kinds of assessments is the brief sensation of exhaustion. At the end of the assessment, your child will be asked to continue to pedal the bicycle at a very easy level until this sensation goes away. The risk of serious illness or death is extremely rare and is reduced by completing the medical screening questionnaire before the assessment and the continuous monitoring we will perform during the assessment.
5. **Accelerometer assessment:** This assessment will require your child to wear a small box the size of a smaller pager clipped onto their pant waist. The accelerometer is designed to measure activity movement that your child performs. We wish for your child to wear the accelerometer from the time they wake up, until they go to bed at night for 7 days. We also ask that the parent complete the Habitual Activity Estimation Scale and our Activity Log. There is no risk associated with this assessment. We will arrange to pick the accelerometer unit at your home.

PART II

The second part of the study would take place approximately 7 days from now at your home. We would come in the morning (before your child has breakfast) and it will only take about 10 minutes. We wish to collect a sample of your child's blood using a finger pinprick technique. The middle finger of your child's non-dominant hand (e.g. if they are right handed, we will use the middle finger of their left hand) will be pricked so two drops of blood can be sampled. Your child will feel a small prick, but will not feel any pain or discomfort for the remainder of the assessment. The tip of that finger may feel sensitive and a little bit sore for about a day. It is important to keep the site clean and covered with an adhesive bandage until it is healed to reduce the risk of infection. We will also use this moment to pick up the accelerometer that you will have had for the past week.

PART III

For this part of the study, we would like you to allow your child's homeroom teacher complete a survey on your child's combined listening, speaking, reading, writing, mathematics and reasoning skills. The name of this survey is the Learning Disabilities Diagnostic Inventory. Despite the name of this survey, we are not looking to diagnose any disabilities in your child's learning ability, nor are the teacher expected to provide a learning disabilities' diagnosis. We simply wish to see how able your child is while learning at school. The results of this assessment will not be shared with your child's school.

Participation and Withdrawal: Your child's participation is voluntary and they are free to withdraw from this study at any time without penalty from Brock University. Further, your child is not required to answer any or all questions or to participate in any aspect of this project.

Confidentiality: All personal data will be kept strictly confidential and all information will be coded so that your child is not associated with their answers. Only the researchers named above will have access to the complete data. Any information we receive will be entered immediately into computer records using a code number with no name attached. It is our intent to continue to publish the results of this research in scientific journals. Again, no personal information will be identified or be possible within any publication.

Information: This study has been reviewed and approved by the Brock University Research Ethics Board, (File#: 07-106) Research Services, Brock University, Room C315 - 905-688-5550 (Ext. 4315). We greatly appreciate your co-operation. If you would like to receive more

information about the study, please contact **Dr. Brent E. Faught** at 905-688-5550, (Ext. 3586). If you are willing to grant permission to participate in this study, please complete the consent form below.

Thanks for your help!

Brent E. Faught, Ph.D.

John A. Hay, Ph.D.

John Cairney, Ph.D.

PARENT CONSENT FORM

I have read and understand the above explanation of the purpose and procedures of the project. My questions have been answered to my satisfaction.

- ☐ I give permission for my child to participate in **Part I** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ As the participating child, I wish to participate in **Part I** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ I give permission for my child to participate in **Part II** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ As the participating child, I wish to participate in **Part II** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ I give permission for my child to participate in **Part III** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ As the participating child, I wish to participate in **Part III** of the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.

OR

- ☐ I do **NOT** give permission for my child to participate in the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.
- ☐ As the participating child, I do **NOT** wish to participate in the Brock University study conducted by Dr. John Hay, Dr. John Cairney and Dr. Brent E. Faught.

Signature of Parent/Guardian: _____

Date: _____

Signature of Student: _____

Date: _____

APPENDIX 4 – Parent Letter of Informed Consent

Principal Investigators: Dr. John A. Hay, Brock University
Dr. John Cairney, University of Toronto and Brock University
Dr. Brent E. Faught, Brock University

Dear Parent/Guardian:

Purpose: The purpose of this study is to investigate healthy growth and development and its association with the physical activity of children for the next three years.

Procedures: We are requesting that you complete five forms as they relate to you and _____ (child's name). These forms will take approximately 40 minutes to complete.

Participation and Withdrawal: As a condition of your participation, we have agreed to provide transportation for you and your child to and from Brock University as well as \$50 for your family's participation in this study. Your participation is voluntary and you are free to withdraw from this study at any time without recourse from Brock University. Further, you are under no obligation to answer any or all questions or to participate in any aspect of this project. If you wish to discontinue participation in this study at any time, you and your child will still receive complementary transportation as well as \$50 for your participation in the study.

Confidentiality: All personal data will be kept strictly confidential and all information will be coded so that you are not associated with your answers. Only the researchers named above will have access to the complete data. Any information we receive will be entered immediately into computer records using a code number with no name attached. It is our intent to continue to publish the results of this research in scientific journals. Again, no personal information will be identified or be possible within any publication.

Information: This study has been reviewed and approved by the Brock University Research Ethics Board, (File#: 07-106) Research Services, Brock University, Room C315 - 905-688-5550 (Ext. 4315). We greatly appreciate your co-operation. If you would like to receive more information about the study, please contact Dr. Brent E. Faught at 905-688-5550, (Ext. 3586). If you are willing to grant permission to participate in this study, please complete the consent form below.

Thanks for your help!

Brent E. Faught, Ph.D.

John A. Hay, Ph.D.

John Cairney, Ph.D.

PARENT CONSENT FORM

I have read and understand the above explanation of the purpose and procedures of the project. My questions have been answered to my satisfaction.


- ☐ I wish to participate for the next three years in this Brock University study conducted by Dr. Brent E. Faught, Dr. John Hay and Dr. John Cairney.
- ☐ I do **NOT** wish to participate in this Brock University study conducted by Dr. Brent E. Faught, Dr. John Hay and Dr. John Cairney.

Signature of Parent/Guardian: _____ Date: _____

APPENDIX 5 - Ratings of Perceived Exertion

| | |
|----|------------------|
| 6 | |
| 7 | VERY, VERY LIGHT |
| 8 | |
| 9 | VERY LIGHT |
| 10 | |
| 11 | FAIRLY LIGHT |
| 12 | |
| 13 | SOMEWHAT HARD |
| 14 | |
| 15 | HARD |
| 16 | |
| 17 | VERY HARD |
| 18 | |
| 19 | VERY, VERY HARD |
| 20 | |

APPENDIX 6 – Movement Assessment Battery for Children, Version 2



Movement Assessment Battery for Children – 2

Test Record Form Age Band 3 (11-16 years)

| | | | | | | | |
|--|---|-------------------|---------------|-------------------|--|--|--|
| Name: | Gender: M / F | | | | | | |
| Home address: | | | | | | | |
| School: | Class/year/grade: | | | | | | |
| Assessed by: | | | | | | | |
| Referral source: | | | | | | | |
| Preferred (writing) hand: | <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33.33%; text-align: center;">Year</td> <td style="width: 33.33%; text-align: center;">Month</td> <td style="width: 33.33%; text-align: center;">Day</td> </tr> <tr> <td style="height: 20px;"></td> <td></td> <td></td> </tr> </table> | Year | Month | Day | | | |
| Year | Month | Day | | | | | |
| | | | | | | | |
| <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33.33%; text-align: center;">Date tested</td> <td style="width: 33.33%; text-align: center;">Date of birth</td> <td style="width: 33.33%; text-align: center;">Chronological age</td> </tr> <tr> <td style="height: 20px;"></td> <td></td> <td></td> </tr> </table> | | Date tested | Date of birth | Chronological age | | | |
| Date tested | Date of birth | Chronological age | | | | | |
| | | | | | | | |

Movement ABC-2 Checklist completed? Y / N

Item Scores and Equivalent Standard Scores

| Item code | Name of item | Raw score (best attempt) | Item Standard Score |
|---|-------------------------------------|--------------------------|---------------------|
| MD 1* | Turning Pegs preferred hand | | |
| | Turning Pegs non-preferred hand | | |
| MD 2 | Triangle with Nails and Bolts | | |
| MD 3 | Drawing Test 3 | | |
| ABC 1 | Catching with one hand – best hand | | |
| | Catching with one hand – other hand | | |
| ABC 2 | Throwing at Wall Target | | |
| Bal 1* | Two-Board Balance | | |
| Bal 2 | Walking Toe-to-Toe Backwards | | |
| Bal 3 | Zig-Zag Hopping best leg | | |
| | Zig-Zag Hopping other leg | | |
| Total Test Score Sum of 6 item standard scores: | | | |

Three Component Scores*

| Manual Dexterity* MD 1 + MD 2 + MD 3 | | |
|--------------------------------------|----------------|-----------------|
| Component score | Standard Score | Percentile Rank |
| | | |

| Aiming & Catching* ABC 1 + ABC 2 | | |
|----------------------------------|----------------|-----------------|
| Component score | Standard Score | Percentile Rank |
| | | |

| Balance* Bal 1 + Bal 2 + Bal 3 | | |
|--------------------------------|----------------|-----------------|
| Component score | Standard Score | Percentile Rank |
| | | |

*In each case sum the item standard scores.

| Total Test Score | Standard Score | Percentile Rank |
|------------------|----------------|-----------------|
| | | |

*For Turning Pegs, Catching with One hand and Zig-Zag hopping, look up standard score for each limb, add these and divide by 2.

Manual Dexterity 1: TURNING PEGS



Record: Preferred hand: R / L (should be same as for Drawing Trail); Time taken (secs); F for failure; R for refusal; I if inappropriate (note reasons below)

| Preferred hand | | Only add a second trial if the first trial takes longer than the time stated below | | | | | | Non-preferred hand | | Only add a second trial if the first trial takes longer than the time stated below | | | | | |
|----------------|--|--|-------------|-------------|-------------|-------------|-------------|--------------------|--|--|-------------|-------------|-------------|-------------|-------------|
| Trial | | 11.0 R/L | 12.0 R/L | 13.0 R/L | 14.0 R/L | 15.0 R/L | 16.0 R/L | Trial | | 11.0 R/L | 12.0 R/L | 13.0 R/L | 14.0 R/L | 15.0 R/L | 16.0 R/L |
| Trial 2 | | 25 sec | 22 sec | 22 sec | 22 sec | 22 sec | 22 sec | Trial 2 | | 21 sec | 20 sec | 20 sec | 19 sec | 19 sec | 19 sec |

Qualitative observations

Posture/body control

- Sitting posture is poor ☐ Hand movements are jerky ☐
- Holds head too close to task ☐ Moves constantly/objects ☐
- Holds head at an odd angle ☐ Adjustment to task requirements ☐
- Does not look while manipulating pegs ☐ Misaligns pegs with respect to holes ☐
- Does not use pincer grip to pick up pegs ☐ Uses excessive force when inserting pegs ☐
- Exaggerates finger movements in releasing pegs ☐ Is exceptionally slow/does not change speed from trial to trial ☐
- Does not use the supporting hand to hold board steady ☐ Goes too fast for accuracy ☐
- Does extremely poorly with one hand (asymmetry striking) ☐ Other ☐
- Changes hands or uses both hands during a trial ☐

Comments: _____

Manual Dexterity 2: TRIANGLE WITH NUTS AND BOLTS



Record: Time taken (secs); F for failure; R for refusal; I if inappropriate (note reasons below)

| No. of seconds | | Only add a second trial if the first trial takes longer than the time stated below | | | | | |
|----------------|--|--|-------------|-------------|-------------|-------------|-------------|
| Trial | | 11.0 R/L | 12.0 R/L | 13.0 R/L | 14.0 R/L | 15.0 R/L | 16.0 R/L |
| Trial 2 | | 21 sec | 20 sec | 20 sec | 19 sec | 19 sec | 19 sec |

Qualitative observations

Posture/body control

- Sitting posture is poor ☐ Hand movements are jerky ☐
- Holds materials too close to face ☐ Moves constantly/objects ☐
- Holds head at an odd angle ☐ Adjustment to task requirements ☐
- Does not look at hole while inserting bolt ☐ Sometimes misses hole with tip of bolt ☐
- Does not use pincer grip to hold nuts and bolts ☐ Gets muddled in the construction sequence ☐
- Finds it difficult to hold bolt with one hand and screw ☐ Is exceptionally slow/does not change speed from trial to trial ☐
- Put on with the other ☐ Goes too fast for accuracy ☐
- Changes hands during a trial ☐ Other ☐

Comments: _____

Manual Dexterity 3: DRAWING TRAIL 3

Note: Bic Atlantis pen to be used

Record: Hand used: R/L/Both; No. of errors; F for failure; R for refusal; I if inappropriate (note reasons below)
Number of errors should be counted after testing using scoring criteria provided in Appendix A of the Manual.

| | No. of errors |
|---------|---------------|
| Trial 1 | |
| Trial 2 | |



Do not administer a second trial if the child completes the first trial perfectly (i.e. no errors).

Qualitative observations

Posture/body control

| | | | |
|-----------------------------------|--------------------------|--|--------------------------|
| Sitting posture is poor | <input type="checkbox"/> | Changes hands during a trial | <input type="checkbox"/> |
| Holds head too near paper | <input type="checkbox"/> | Moves constantly/fidgets | <input type="checkbox"/> |
| Holds head at an odd angle | <input type="checkbox"/> | Adjustment to task requirements | <input type="checkbox"/> |
| Does not look at trail | <input type="checkbox"/> | Progresses in short jerky movements | <input type="checkbox"/> |
| Holds pen with an odd/mature grip | <input type="checkbox"/> | Uses excessive force, presses very hard on paper | <input type="checkbox"/> |
| Holds pen too far from point | <input type="checkbox"/> | Is exceptionally slow | <input type="checkbox"/> |
| Holds pen too close to point | <input type="checkbox"/> | Goes too fast for accuracy | <input type="checkbox"/> |
| Does not hold paper still | <input type="checkbox"/> | Other | <input type="checkbox"/> |

Comments: _____

Aiming & Catching 1: CATCHING WITH ONE HAND

Record: Number of correctly executed catches; R for refusal; I if inappropriate (note reasons below)

| | | | |
|--|-----------|---|--------------|
| Right Hand Practice: <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | 10 Trials | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Total: _____ |
| Left Hand Practice: <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | 10 Trials | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Total: _____ |

Qualitative observations

Posture/body control

| | | | |
|---|--------------------------|---|--------------------------|
| Standing posture is poor | <input type="checkbox"/> | Adjustment to task requirements | <input type="checkbox"/> |
| Does not follow trajectory of ball with eyes | <input type="checkbox"/> | Does not adjust body position for catching | <input type="checkbox"/> |
| Turns away or closes eyes as ball approaches | <input type="checkbox"/> | Does not adjust position of feet as necessary | <input type="checkbox"/> |
| Holds hand out flat with fingers stiff as the ball rebounds | <input type="checkbox"/> | Judges force of throw poorly (too much or too little) | <input type="checkbox"/> |
| Hands and arms held wide apart, fingers extended | <input type="checkbox"/> | Does not adjust to height of rebound | <input type="checkbox"/> |
| Arm and hand do not 'give' to meet impact of ball | <input type="checkbox"/> | Does not adjust to direction of rebound | <input type="checkbox"/> |
| Fingers close too early or too late | <input type="checkbox"/> | Does not adjust to force of rebound | <input type="checkbox"/> |
| Does extremely poorly with one hand (asymmetry striking) | <input type="checkbox"/> | Other | <input type="checkbox"/> |
| Movements lack fluency | <input type="checkbox"/> | | |

Aiming & Catching 2: THROWING AT WALL TARGET

Record: Hand used: R / L / Both; Number of successful hits; R for refusal; I if inappropriate (note reasons below)

Practice: ☐ ☐ ☐ ☐ ☐ 10 Trials: ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Total: _____

Qualitative observations

Posture/body control

Balance while throwing is poor

Does not keep eyes on target

Does not follow through with the throwing arm

Releases ball too early or too late

Changes hands from trial to trial

Movements lack fluency

Adjustment to task requirements

Errors are consistently to one side of the target

Asymmetry (sking)

Control of direction is variable

Judges force of throw poorly (too much or too little)

Control of force is variable

Other _____

Comments: _____

Balance 1: TWO-BOARD BALANCE



Record: Time balanced (secs); R for refusal; I if inappropriate (note reasons below)

| | No. of seconds |
|---------|----------------|
| Trial 1 | |
| Trial 2 | |



Do not administer a second trial if the child maintains balance for 30 seconds.

Qualitative observations

Posture/body control

Body appears rigid/tense

Body appears limp/loose

Sways wildly to try to maintain balance

Does not hold head and eyes steady

Makes no or few compensatory arm movements

to help maintain balance

Exaggerated movements of arms and trunk disrupt balance

Cannot hold feet in a straight line

Other _____

Comments: _____

Balance 2: WALKING TOE-TO-HEEL BACKWARDS

Record: Number of correct consecutive steps from the beginning of the line; Whether entire line was walked successfully; R for refusal; I if inappropriate (note reasons below)

| | No. of steps | Entire line? |
|---------|--------------|--------------|
| Trial 1 | | YES / NO |
| Trial 2 | | YES / NO |



Do not administer a second trial if the child completes 15 steps OR completes the whole line in fewer than 15 correctly executed steps.

Qualitative observations:

Posture/body control

- Body appears rigid/tense ☐
- Body appears limp/floppy ☐
- Sways widely to try to maintain balance ☐
- Does not look behind to check position on track ☐
- Does not compensate with arms to maintain balance ☐
- Exaggerated arm movements disrupt balance ☐
- Is very wobbly when placing feet on line ☐

Adjustments to task requirements

- Goes too fast for accuracy ☐
- Individual movements lack smoothness and fluency ☐
- Sequencing of steps is not smooth/pauses frequently ☐
- Other ☐

Comments: _____

Balance 3: ZIG-ZAG HOPPING

Record: Number of correct consecutive hops (maximum of 5); R for refusal; I if inappropriate (note reasons below)

| | | No. of hops | | | No. of hops |
|-----------|---------|-------------|----------|---------|-------------|
| Right Leg | Trial 1 | | Left Leg | Trial 1 | |
| | Trial 2 | | | Trial 2 | |



Do not administer a second trial if the child completes 5 perfect hops on the first trial.

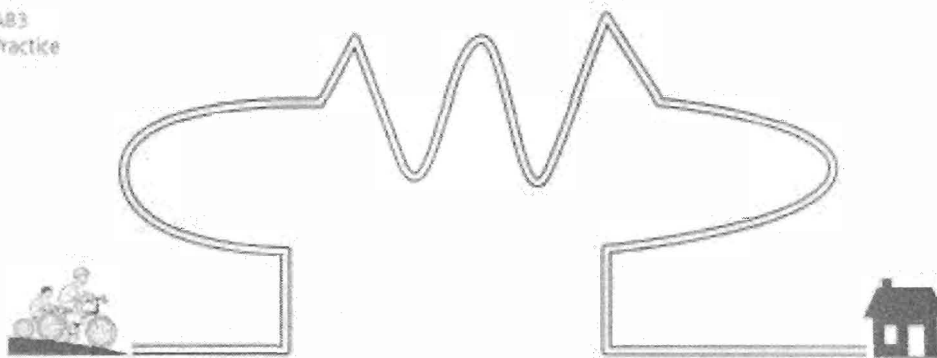
Qualitative observations:

Posture/body control

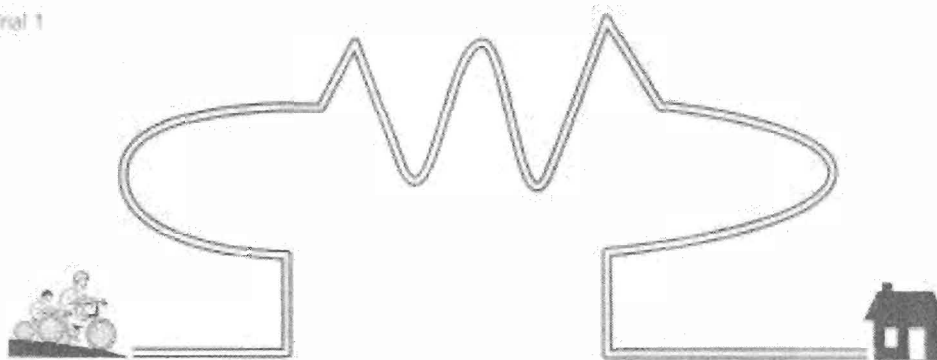
- Body appears rigid/tense ☐
- Body appears limp/floppy ☐
- Non-supporting leg held up in front of body ☐
- Hops with stiff legs/in flat feet ☐
- Lacks springiness/no push-off from feet ☐
- Arm movements are exaggerated ☐
- Does not use arms to assist hop ☐
- Stumbles on landing ☐

- Goes extremely poorly with one leg (asymmetry striking) ☐
- Adjustments to task requirements ☐
- Goes too fast for accuracy ☐
- Does not combine upward and forward movements effectively ☐
- Uses too much effort ☐
- Movements are jerky ☐
- Other ☐

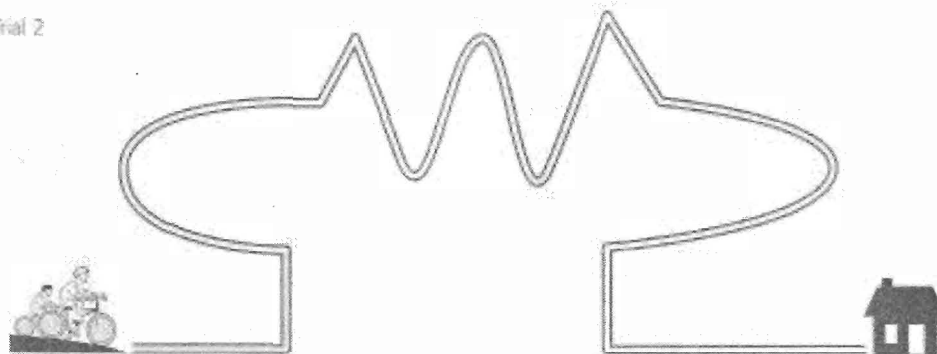
A83
Practice



Trial 1



Trial 2



NON-MOTOR FACTORS THAT MIGHT AFFECT MOVEMENT

Complete the sections below by noting any features of the child's behaviour during testing that you suspect might have affected his or her motor performance. Headings (with examples) are given as guidelines only. Although negative aspects are given more emphasis, remember to note positive aspects of the child's behaviour.

| | Yes | No |
|---|--|----|
| 1. Disorganised (e.g. scattered clothes slows up dressing after PE; puts on shoes before socks). | | |
| 2. Hesitant/forgetful (e.g. slow to start complex actions; forgets what to do in the middle of an action sequence). | | |
| 3. Passive (e.g. hard to interest, requires much encouragement to participate). | | |
| 4. Timid (e.g. fearful of activities such as jumping/climbing; constantly asks for assistance). | | |
| 5. Anxious (e.g. trembles; becomes flustered in a stressful situation). | | |
| 6. Impulsive (e.g. starts before instructions are complete; impatient of detail). | | |
| 7. Distractible (e.g. looks around, responds to irrelevant noises). | | |
| 8. Overactive (e.g. squirms and fidgets; moves constantly when listening to instructions, fiddles with clothes). | | |
| 9. Overestimates own ability (e.g. tries to make tasks more difficult; tries to do things too fast). | | |
| 10. Underestimates own ability (e.g. complains of task difficulty; anticipates failure before starting). | | |
| 11. Lacks persistence (e.g. gives up quickly; is easily frustrated). | | |
| 12. Upset by failure (e.g. looks tearful, refuses to try task again). | | |
| 13. Unable to get pleasure from success (e.g. fails to respond to praise). | | |
| Other (please specify): | | |
| Overall, do you think these problems prevent the child from demonstrating his or her true movement capability (please circle) | not at all a little a great deal | |

PHYSICAL FACTORS THAT MIGHT AFFECT MOVEMENT

| | |
|---|--------------------------|
| Anatomical/postural defect: YES/NO | Specify, if possible |
| Vision defect: YES/NO | Hearing defect: YES / NO |
| Judgement of weight: average/overweight/underweight | |
| Judgement of height: average/tall/short | |
| Other: | |

Table 2a: Brief summary of changes made to AB1 – now covers ages 3 to 6 years

| Task | Movement ABC AB1 | Movement ABC-2 AB1 |
|---------------------|------------------------|-----------------------------|
| Manual Dexterity 1 | Posting Coins | Posting Coins |
| Manual Dexterity 2 | Threading Beads | Threading Beads |
| Manual Dexterity 3 | Bicycle Trail | Drawing Trail 1* |
| Aiming & Catching 1 | Catching Beanbag | Catching Beanbag |
| Aiming & Catching 2 | Rolling Ball into Goal | Throwing Beanbag onto Mat** |
| Balance 1 | One-Leg Balance | One-Leg Balance |
| Balance 2 | Walking Heels Raised | Walking Heels Raised |
| Balance 3 | Jumping over Cord | Jumping on Mats** |

* Altered item: shape of trail has changed

** New item

Table 2b: Brief summary of changes made to AB2 and AB3 – now labelled AB2 and covers ages 7 to 10 years

| Task | Movement ABC AB2 | Movement ABC AB3 | Movement ABC-2 AB2 |
|---------------------|---------------------------|---------------------------|------------------------------|
| Manual Dexterity 1 | Placing Pegs | Shifting Pegs by Rows | Placing Pegs- |
| Manual Dexterity 2 | Threading Lace | Threading Nuts on Bolt | Threading Lace^ |
| Manual Dexterity 3 | Flower Trail | Flower Trail | Drawing Trail 2* |
| Aiming & Catching 1 | Two-Hand Catch | One-Hand Bounce and Catch | Catching with Two Hands |
| Aiming & Catching 2 | Throwing Beanbag into Box | Throwing Beanbag into Box | Throwing Beanbag onto Mat** |
| Balance 1 | Stork Balance | One-Board Balance | One-Board Balance |
| Balance 2 | Heel-to-Toe Walking | Ball Balance | Walking Heel-to-Toe Forwards |
| Balance 3 | Jumping in Squares | Hopping in Squares | Hopping on Mats+ |

Altered items:

- New start position/layout

^ Lacing board now longer

* Shape of trail has changed

** Mat with target now used instead of box

+ Mats used for this task

Table 2c: Brief summary of changes made to AB4 – now labelled AB3, covering ages 11 to 16

| Task | Movement ABC | Movement ABC-2 |
|---------------------|-------------------------|-------------------------------|
| Manual Dexterity 1 | Turning Pegs | Turning Pegs |
| Manual Dexterity 2 | Cutting-Out Elephant | Triangle with Nuts and Bolts^ |
| Manual Dexterity 3 | Flower Trail | Drawing Trail 3* |
| Aiming & Catching 1 | One-Hand Catch | Catching with One Hand |
| Aiming & Catching 2 | Throwing at Wall Target | Throwing at Wall Target |
| Balance 1 | Two-Board Balance | Two-Board Balance |
| Balance 2 | Walking Backwards | Walking Toe-to-Heel Backwards |
| Balance 3 | Jumping and Clapping | Zig-Zag Hopping^ |

^ New items

* Altered item: Shape of trail has changed

APPENDIX 7— Children completed the Children Self-Perceptions of Adequacy in and Predilection for Physical Activity (CSAPPA)

Appendix 5 – The CSAPPA Scale used in Canada

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CSAPPA SCALE

Name: _____ Birth date: ____ / ____ / ____ Age: ____ years
MM DD YY

Grade: _____ Gender: M / F

INSTRUCTIONS:

PLEASE RESPECT YOUR FELLOW STUDENTS PRIVACY BY KEEPING YOUR EYES ON YOUR OWN PAPER! In this survey you have to read a pair of sentences and then circle (O) the sentence you think is **MORE LIKE YOU**.

Try the following example.

SAMPLE QUESTION

Some kids have one
nose on their faces!

BUT

Other kids have three
noses on their faces!

That shouldn't be too hard for you to decide! Once you have circled the sentence that is more like you, then you have to decide if it is **REALLY TRUE** for you or **SORT OF TRUE** for you.

Here is another sample question for you to try. Remember, first circle the sentence that is more like you and then put a check (✓) in the correct box if it is really true or only sort of true for you. THERE ARE NO CORRECT OR INCORRECT ANSWERS, JUST WHAT IS **MOST LIKE YOU**.

SAMPLE QUESTION

REALLY
TRUE
for me

SORT OF
TRUE
for me

☐
☐

Some kids like to
play with computers.

BUT

Other kids don't like
playing with computers.

SORT OF
TRUE
for me

REALLY
TRUE
for me

☐
☐

Now you are ready to start filling in this form. Take your time and do the whole form carefully. If you have any questions just ask! If you think you are ready you can start now. BE SURE TO FILL IN BOTH SIDES OF EACH PAGE!

| REALLY TRUE for me | SORT OF TRUE for me | | | | SORT OF TRUE for me | REALLY TRUE for me |
|--------------------------|---------------------------|---|-----|---|---------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids can't wait to play active games after school. | BUT | Other kids would rather do something else. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids really enjoy physical education class. | BUT | Other kids don't like physical education class. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids don't like playing active games. | BUT | Other kids really like playing active games. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids don't have much fun playing sports. | BUT | Other kids have a good time playing sports. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids think physical education is the best class. | BUT | Other kids think physical education isn't much fun. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids are good at active games. | BUT | Other kids find active games hard to play. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids don't like playing sports. | BUT | Other kids really enjoy playing sports. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids always hurt themselves when they play sports. | BUT | Other kids never hurt themselves playing sports. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids like to play active games outside. | BUT | Other kids would rather read or play video games. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids do well in most sports. | BUT | Other kids feel they aren't good at sports. | <input type="checkbox"/> | <input type="checkbox"/> |

| REALLY TRUE for me | SORT OF TRUE for me | | | | SORT OF TRUE for me | REALLY TRUE for me |
|--------------------------|---------------------------|---|-----|--|---------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids learn to play active games easily. | BUT | Other kids find it hard learning to play active games. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids think they are the best at sports. | BUT | Other kids think they aren't good at sports. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids find games in physical education hard to play. | BUT | Other kids are good at games in physical education. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids like to watch games being played outside. | BUT | Other kids would rather play active games outside. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids are among the last to be chosen for active games. | BUT | Other kids are usually picked to play first. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids like to take it easy during recess. | BUT | Other kids would rather play active games. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids have fun in physical education class. | BUT | Other kids would rather miss physical education class. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids aren't good enough for sports teams. | BUT | Other kids do well on sports teams. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids like to read or play quiet games. | BUT | Other kids like to play active games. | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | Some kids like to play active games outside on weekends. | BUT | Other kids like to relax and watch TV on weekends. | <input type="checkbox"/> | <input type="checkbox"/> |

THANK YOU VERY MUCH FOR COMPLETING THE CSAPPA SCALE! ☺

APPENDIX 8 - Tanner staging pictures

Male Pubertal Stage

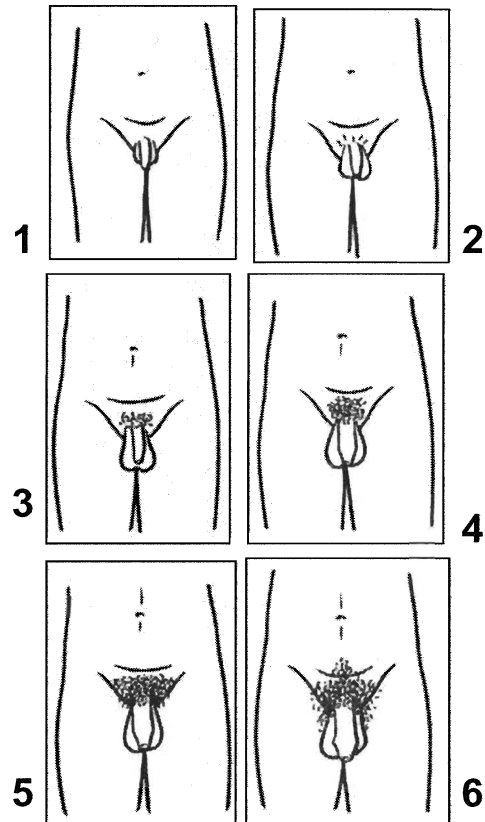
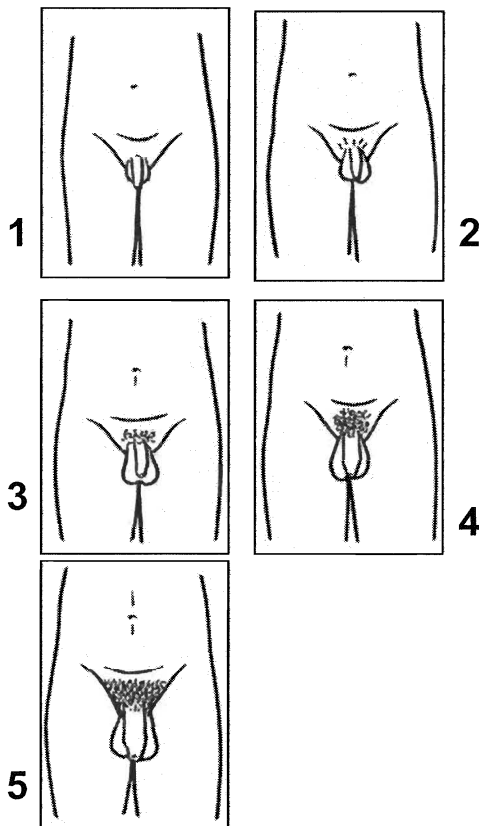
FACULTY OF APPLIED HEALTH SCIENCES

BROCK UNIVERSITY

This survey will be used to assess the maturational levels of the participant. For each photo choose the appropriate stage and place an X in the corresponding square.

- Please circle the box that looks most like you
- Please look at the penis size only

- Please look at the pubic hair only
- Please circle the box that looks most like you



Female Pubertal Stage

BROCK UNIVERSITY

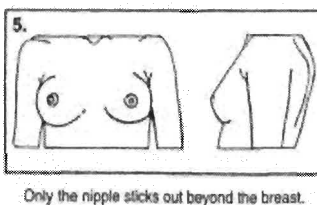
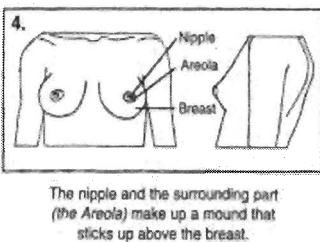
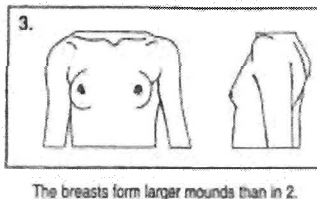
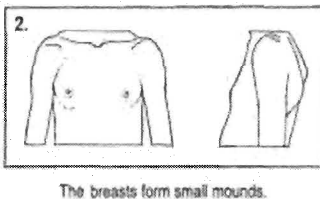
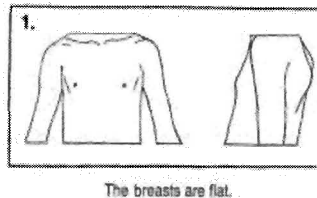
FACULTY OF APPLIED HEALTH SCIENCES

This survey will be used to assess the maturational levels of the participant. For each photo choose the appropriate stage and place an X in the corresponding square.

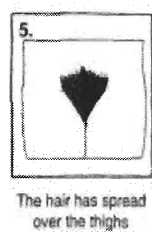
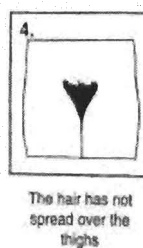
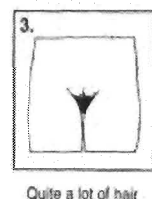
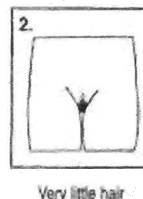
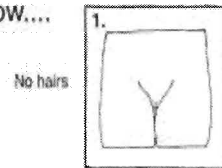
Directions: You should choose only one of the stages shown below. One stage for Breast development and one stage for Pubic Hair development.

Study Subject No:

- Please put a tick in the box that looks most like you now....



- Please put a tick in the box that looks most like you now....



Please answer the following questions:

1. Have you had your period? YES NO
2. How old were you when you had your first period? _____
3. How often do you get periods? (in days) _____

APPENDIX 9 – Accelerometer Log Book

Child's Name _____ Date: _____

Dear Parent,

Thank you very much for allowing your child to be part of this part of the PHAST study!

The small device that your child will wear for the next week is called the Actigraph. It is rugged and water- proof and is used to measure activity by counting all the times your child's body moves. There are no buttons to play with or display to look at so you do not have to worry about accidentally changing a setting or losing the stored information. We would only ask that it be kept away from strong magnets and that it is taken off when your child takes a bath/shower or goes swimming. Getting wet doesn't harm the Actigraph but the belt it is attached to would get soggy and be uncomfortable to wear!

WHEN YOU ATTACH THE BELT WITH THE ACTIGRAPH PLEASE MAKE SURE THE GREEN SIDE IS FACING UP (CAN BE SEEN BY YOUR CHILD)!

To help us understand the results we see from the Actigraph we do need your help! Please mark down on the attached pages the time it was put on in the morning and taken off at night. If the Actigraph was taken off for other reasons please tell us those times and the reason it was taken off. The following sheets will let you write down those times for us.

The last few pages are a short questionnaire called "Two Days in the Life of My Child" This form takes about 10 minutes to complete. The instructions are quite clear but if you have any questions please do not hesitate to contact us! This form should be completed the day before we come to pick up the Actigraph.

Thanks once again for your efforts on our behalf. This is important research and we could not do this without you!

START DATE: _____

Day 1: Time put on in the morning: _____

Time taken off at bedtime: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 2: Time put on in the morning: _____

Time taken off at bedtime: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 3: Time put on in the morning: _____

Time taken off at bedtime: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 4: Time put on in the morning: _____

Time taken off at bedtime: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 5: Time put on in the morning: _____

Time taken off at bedtime: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 6: Time put on in the morning: _____

Time taken off at bedtime: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Day 7: Time put on in the morning: _____

Time taken off at bedtime: _____

Times taken off during the day: off: _____ back on: _____ Reason:

off: _____ back on: _____ Reason:

Thanks! Could you please now complete the form on the next few pages! It does not take long to complete and the information you provide to us will be very helpful!